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1 Mechanicks is the part of Philosophy, which treats of the Nature and laws of Motion.

2 What is to be said on this Subject may be reduced to 3 heads. under the first we shall explain, the nature of Machines considering the actions and powers of Weights acting continually against obstacles and other resistances. Under the second we shall speak of those laws, which relate to the effects of moving forces upon such bodies as are at liberty to move without any obstacle or resistance. In the 3d place we shall apply these forementioned laws to the Motions of Heavenly bodies and shew that the whole planetary System is governed by them.

Of Motion in general.

3 Motion is a continual shifting out of one place into another without continuing in the same place any time. That affection of Motion by which a body runs thro' a certain space in a certain time, is call'd the Celerity or Velocity of Motion. The greater the force impressed upon a Body to make it change its place, is, the greater is its Motion (for the effect is allways proportionable to the cause) and the force is call'd ye Momentum or quantity of Motion. The Momentum of any

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Body may be considered as the Rectangle under y^e Quantity of Matter and Velocity.

4. Of Motions Compared together

Bodies of Motion can but differ in 2 respects, either in the Quantity of Matter in each, or in the velocity; threfore only these two are to be consider'd in Comparing of Motions. Whence we deduce the following Rules.

5. First, In equal Velocities the Masses only are to be consider'd; here if the Masses be equal, the momentum in each will be as the Mass in each viz equal; if the Masses are v.g. 3 quant. in A, 1 in B, then the Momentum of A will be thrice the Momentum in B; for A is made up of 3 such Bodies as B, each of which moves with the same velocity as B does.

6. Secondly. In equal Masses the velocities are only to be considered, here since a double velocity cannot be impressed upon an equal Mass of Matter without a double Momentum, it follows that if two equal Bodies move uniformly with unequal velocities, the Quantities of Motion will be directly as their Velocities.

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7. 3.d If both the Masses and Velocities are unequal, the Quan=
=tity of Motion will be in a compound ratio of the Masses and Velocities; wherefore in Order to deter=
=mine the relation between two such Motions, two Quantities are to be found that are to one another as the Masses and Velocities and then by Multiply=
=ing the Mass of each Body by its Velocity, the pro=
=ducts will be to each other in the said propor=
=tion; thus let A have 3 degrees of Velocity, and 6 of Mass, B have 2 degrees of Velocity, and 3 of Mass, the quantity of Motion in A will be $3 \times 6 = 18$. in B $2 \times 3 = 6$, therefore the Quantities of Motion will be to one another as 18 to 6 or 3 to 1.

8 4th, When the Velocity of a lesser Body, is to the Velocity of the greater, as the Mass of the greater is to the Mass of the less, the Quantities of Motion will be equal in these two Bodies, for as much as the Quan=
=tity of Motion is less in respect of its Mass, so much it is

greater in respect of its Velocity; so vice versa, in the greater Weight, whence arises an equality of Motion or an equilibrium in the two Bodies. In the same manner as we have compared the Quantities of Moti=on, may allso be compared the quantities of the Actions.

Of Powers Compar'd together.

9. The Actions of Powers can differ but in two re=spects, either in the Greatness of the obstacles or in Velocities i:e: the spaces run thro by those obstacles. from whence it is, first, That when the powers are equal viz: have equal intensitities, their actions will be to one another as their velocities. Secondly, In equal velocities those actions will be to one another as their intensities: Thirdly. When both the intensities & velocities are unequal, the action of the powers will be to one another in a compound ratio of the Velocities and In=tensities therefore: Fourthly, Where the velocity of a lesser power

is to the velocity of a greater; as the intensity of the greater, is to the intensity of the less, the actions of the two powers will be equal, from this Rule. The Doctrine of Powers compar'd together are all deduced from this single consideration, that velocity is equivolent to force.

The Nature of Several Sorts of Machines Explain'd.

10. A Machine is any thing by which a Body is either mov'd or hinder'd from moving. The Body to be moved or stoped is call'd the weight, that which moves or sustains a weight, is called, a Power, that point of a Machine about which a Body (i e the weight) and power move, is call'd the fixt point or fulcrum, and from this point is the distance of the weight or power to be computed.

11. The Nature of any Machine is said to be explain'd, when it is known in what circumstance it will be in equilibrio, viz: in what circumstances the Quantites of Motion in the Weight and power will

{Of the balance or leaver. Prop. 1. } Vid: Roh: part. 1st. Cha: 14: Notes
propo: 1st.

If two forces, which act upon the arms of a balance in given directions that are in the plain with those arms balance one another; these forces are to each other reciprocally, as perpendiculars let fall from the Center of the balance; to their directions.

Dem: (See Newt: Princ: pag: 14.

Let C be the Center of the balance. cp, CP, the arms, Ep, PA, the directions of the forces acting upon the arms cp, CP. Let CE, be drawn

Fig: 1. perpendicular to pE, and CD, to PA, meeting them in E and D. On the Center C, and with the Radius CE, viz the longest of the perpendiculars let a circle be described which shall intersect the direction of the force P in A, and let the line CA be drawn: to which let AG be drawn perpendicular, and GF parallel, meeting DPA in F.

It is evident, that the arms of the balance CP, and Cp, may be looked upon as lines that will not bend, laying in the plain moveable about the Center C, and the same may be understood of any other line drawn through the Center C, and laying the same plain. Now since it is manifest that there is no difference on what points of the lines, in which the forces P and p act, those forces are placed, since wheresoever they are in those lines, they will have exactly the same power to turn the plain, CDApE

be equal: N:B: A Machine will be in equilibrio, when the velocities of the forces are reciprocally, as their Quantities (see the end of the 9th sect) now according to this method we will breifly explain the nature of five Simple Machines.

First of the Lever.

n:[illegible] Lever is an inflexable right line, made use of to raise weights, either weighing nothing themselves, or such a weight as may be ballanc'd. Theorem In this, which is the most simple of all Machines, the power and the weight will be in equilibrio, when the distance of the power is to that of the weight, as the weight is to the intensity of the power; this wants but little demonstrating after what has been said before, and may be fetched from sect; the eight and ninth.

N:B: In a Lever the spaces run through are as the distances from the Center. The Nature of the Lever being now well understood it will be superfluous to say any thing of the

Ballance and Steel-yard. Wherefore in the second place we shall proceed to treat of

The Axis in Peritrochio.

13 The Axis in Peritrochio is a wheel, that turns round together with its axis, the power in this Machine is apply'd to the circumference of the wheel, by whose motion a rope, that is tied to the weight, is woun'd about the axis, by which the weight is rais'd. Theorem. That there may be an Equilibrium in this Machine between the weight and the power it is requisite that the Diameter of the wheel be to the Diameter of the Axis inversely as the power is to the weight; for let AB be the wheel DE the axis, P the weight, M the power. Dem: As the wheel is moved by the power the points B and D Describe similar arcs, which ~~arcs~~ are the spaces run thro' by the power and the weight, and are to eachother

as CB to CD i.e: as the Diameter of the Wheel is to
Fig1 that of the axis, wherefore in one revolution of the wheel, the velocity of the power will be reciprocally to the velocity of the weight, as the power is to ye weight. Whence will arise an equilibrium, and if ye power be never so little encreased it will raise the weight.

Thirdly of the Pulley. Vid: Roh: pa:1: Cha:14 notes. pro:5.

14 A pulley is a Machine composed of one or more wheels moveable about their Axes, about which goes a rope drawing up the weight. A single pulley if its axis be fixed serves only to alter the direction of the power and is of no use; for the power can't move at all unless the obstacle at the same moves thro' an equal space. Theorem. But in a pulley not fixed, where the rope runs under it or in a combination of Several pulleys the force ~~which~~ is to the weight
Fig2 as 1 to the number of Ropes, by which the weight is

suspended, will be able to poise the weight, and the least augmentation will raise it.

Demonstration.

For when one end of the rope is fastned at B, the pulley and weight hung in the displication of the rope, are as it were sustain'd by two ropes NB & Pn in such a manner that if we raise the pulleys and weight one foot the power must move thro' two feet. Whence the space run over by the power, will be double to that of the weight, therefore if the power be to the weight as one to two its momentum will =^{e} that of the weight; for the same reason if 3 pulleys be made use of the velocity of the power will be triple to that of the weight, and in all cases the velocity of the power, will be to that of the weight as the number of ropes sustaining the weight is to one.

Fourthly of the Screw. Vid: Roh: pa:1: Cha: 14. pro: 4.

15 A Screw is a Cylender equally divided into an Heliacal or winding form, when a convex surface is cut in the instrument it is call'd a Male screw, and the protuberant Heliacal part is call'd the thread; when a concave surface is cut then it is call'd a Female screw.

Theorem.

In the Screw when the space described by one revolution of the power is to the distance between two Heliacal threads that are contiguous as the resistance of the weight to be moved is to the intensity of the power, which turns the screw, there will be an equilibrium.

Demonstration.

It is manifest by the mere sight of the Machine y^t in one revolution of the Screw, the weight will be moved thro' a space equal to the compass it

NB Sr Isaac considers the wedge as 2 inclined [illegible] plains, and reduces the screw to a wedge. Cor. 2. ad. leg. Mot: Prin: L. 1.

takes in one revolution, i:e: the space run thro' by the weight, will be to that of the power described in the same time as the distance between two threads to the Compass described by the power in the same time, therefore when the space described by the power is to the distance of any 2 threads as the resistance of the weight to the Intensity of the power there will be an equilibrium.

Fifthly of the Wedge. Vid: Roh: pa: 1: cha: 14 prop: 5.

18. A wedge is an instrument made use of to overcome ye tenacity of Bodies, the form is that of a prism of a small Height, whose opposite Bases are Equicrural triangles.

Theorem.

If the power applyed directly to the back of the wedge be to the resistance, which is to be overcome by the wedge as the thickness of the wedge is to its Height, there will be an equality, and if the power

be ever so little encreased it will overcome the resistance

Demonstration.

For when the whole wedge is driven in the space gone thro' by means of the force is the Height of the wedge, & the space which the Body goes thro' as it yeilds to each side is the Base of the wedge; whence it follows that in an equilibrio, the power is to the resistance of the Body, as the Base is to the Height of the wedge, hence the greater the height and the thinner the Base, the more forcibly it will act, the height of the wedge answering to the distance of a power applyed to a Lever.

17. These are the 5 Machines on which all Mechanical pow-ers depend; all compound Machines being nothing else, but different modifications of some one or more of these simple ones, wherefore in estimating the forces of Compound Machines, we have nothing else

×Was the saying of Archimedes to Hiero King of Sicily.
datum pondus datâ vi movere, Newt: Princ: L1: Sch:
ad leg Mot:

to do, but to compute what would be the y^e^ proportion of the weights and powers, and to take their forces in reciprocal proportion of their velocities. A more full account of both simple and compound Machines may be found in Wilkins, notes and Watts &c. whose designs led 'em to it.

18 But before we leave this head, we must observe that it is not the work of any Machine to encrease the absolute force of any power, which indeed is impos=sible to be done, but only by a certain application to diminish the velocity of the weight or encrease that of the power in such a manner that the momentum of the weight be render'd less than the momentum of the power, w^ch^ might be done to the degree as to move the whole globe of the Earth, δος πȣ̃ ϛῶ κ̀ τὴν γῆν κινήσω. ~~Archi~~:

Part the Second.

19 We come now to our second head in which we were to speak of Free and undisturbed Motions,

NB S^r Isaac was not the inventer of these Laws of Nature; for they are almost the same words in Cartesius's Principia, as in S^r Isaac's. but he was y^e first that applied them to the greater Bodies of the Universe.

in which we are to consider Bodies as left to themselves, and continuing in motion with=out resitances the laws by which Bodies so moving are governed, are called by Sr Isaac Newton the laws of Nature, they being such as all natural Bodies necessarily obey.

Of the Laws of Nature.

20 Sr Isaac Newton has therefore laid down 3 Laws, by which, every thing that relates to motion may be explain'd. First, all Bodies continue in their state of rest, or motion uniformly in a right line, except so much as they are impelled to change that state by forces impressed. For we see that all Bodies are in their own nature curative, and therefore are not so much as capable of moving them=selves; wherefore unless they are mov'd by some ex=ternal agent, they must necessarily remain forever

at rest; for the same reason being once put into motion they must continue it in a right line according to the direction of the impulse they receive; for a body of it=self can no more turn out of the way it is in or put an end to its motion once begun; than it can put itself into motion at first, as it is evident from the inertia of Matter, or the force whereby it resists all changes; this indeed at first sight may seem a diffi=culty, because we are so much conversant about the motions of Projectiles which we see always languishes and dies away by degrees, but the reason of that re=tardation (which we shall explain below) being once understood, the difficulty will easily vanish.

21. 2^d. The alteration of motion is allways proportionable to the moving force impress'd and in the same direction as the force. The cause is always propor=tionable to the effect, therefore if any force generates

any motion a double force will generate a double mo=
=tion, and a triple force a triple motion &c and because ye
force is always that which determines the motion, it
must (by the first Law of Nature) be always perform=
=ed in the same direction with it, till some new force
turn it out of that direction; and the motion pro=
=duc'd by the Impress'd force will be either coincident
with, opposite or oblique motions to the former;
so that to determine the motion after this impulse
in the first case, the two motions must be added
together; in the second the less must be substracted
from the greater; in the third they must be com=
=pounded, so that the motion must from thence for=
=ward be perform'd according to the determination of
both.

22 III. Action and reaction are always equal and in con=
=trary directions to each other: If any Body impinges
upon another that is at rest, the moving Body loses
just the same quantity of motion the other gains; If

press a stone with my hand, my hand is equally press'd by the stone; thus also the Load-stone draws Iron & is equally drawn by it, which appears from experi=ment. For if a peice of Iron and a Loadstone be fastned each to a peice of Cork and set a float in the water; they will equally advance towards each other and meet with velocities reciprocal to their masses or quan=tities of Matter. Having taken a general vew of the Laws of Nature, we shall next consider some of the most use=full Theorems relating to the several sorts of moving Bodies in order, as they are deduced from some of the foregoing laws.

From the first are only deduced a Few Theorems of Central forces and Circular Motions.

23. A Body in motion, according to this Law continues its motion in a right Line, till a new impulse acts upon it and turns it out of its way; when such a new impulse comes from one certain fix'd point; and acts

every moment upon a moving Body, that Body will de=
=scribe a curve line round that point; thus a stone
whirl'd about in a sling describes a curve, because
the string doth every moment, as it were, draw it back=
=ward to the hand, but if the string be broken, or let
go, it will fly off in a Tangent to that curve; the force
by which it recedes from the Centre in this case, is call'd
a centrifugal force; that by which it is impell'd to the
Centre, is call'd a Centripetal force, and (by a name
common to them both) these are call'd central Forces.
The time in which a Body performs one revolution
round a centre, is call'd its periodical time.

24 The following Theorems concerning Centripetal forces are
demonstrated Geometrically by Whiston, Huygens, & others;
and proved experimentally by Gravesende.

First, that if two Bodies revolve about different Centres
at equal distances ~~the Centripetal forces will be~~

in equal Periodical times, the Centripetal forces will be directly as the quantity of Matter.---------

Secondly. That in equal quantities of Matter, and equal Periodical times, the Centripetal forces are as their distances.-----------------------------

Thirdly. That in equal Quantities of Matter, and equal distances, the Centripetal forces will be inverse=ly as the squares of the times, or (which is the same) directly as the squares of their velocities. - - - - - - -

Fourthly. That if the quantities of Matter and the velocities are equal, the Centripetal forces will inverse=ly as their distances.

Fifthly. If only the Quantities of Matter are equal; the Centripetal forces will be in a compound Ratio of the distances reciprocally & the 2res of their velocities directly.

Sixthly. That if the Centripetal forces be in diverse dis=tances, from the Centre reciprocally as the 2res of

those distances, then the proportion of the periodical times duplicated, will be equal to the proportion of their distances triplicated i.e. the squares of the Perio-dical times will be betwixt themselves as the Cubes of their distances are.

25. The same holds good as well in Eliptical as circular motions provided the middle distance between the greatest and least be taken; an Elipsis is an Oval Curve in which there are two points C, D call'd the Focis

Fig. 4 the point toward which the Centripetal force tends falls in with one of them, as C; so that in every revo-lution the Body moves in such a manner as to describe areas proportional to the times, i.e. that the areas described in equal times shall be equall. Thus if a Body being E, in the space of an hour moves thro' an ark E F; describing (by a line drawn from its Centre to the

attracting Focus) the area ECF, it will in the next hour move with such a velocity, that the content of the area it describes, shall be equal to the content of the area it described in the last hour, when it has got to G, it will in an hours time run thro the area GH, and describe the area GCH = the area ECF; whence it follows that in each revolution the Body must be retarded as it recedes from its least distance, as when it goes from H thro P and E and accelerated as it approches towards its least distance passing thro F, G to H.

26 Motions deduced from y^e 2^d Law of Nature relating to — — — — — — —

1. y^e perpendicular motion of heavie bodies. 2. y^e motion of projectiles. 3. y^e descent of heavy bodies on inclined plains. 4. y^e Vibrations of pendulums. 5. y^e Compound motion arising

fro Obliq^e forces. — — ——

1.st of y^e Perpendicular motio of heavy Bodies.

207 By y^e perpendicular motio of heavy Bodies is meant y^e Ascent & Descent in lines perpendi cular to y^e Surface of y^e Earth; wch y^e former then are accelerated by y^e force of gravity (acts conspiring wth their motio) & y^e latter in a contrary reason are retarded. we shall here consid^r Bodies as gravitating equally at all distances fro y^e Earth, for y^t gravity doth really decrease as the □^s of y^e distances increase, yet so small is y^e height to wch projectiles can be thrown y^t there can be no diff^ce [illegible] there . . .

208 1.st y^t y^e motio of Bodies falling by their gravity is an equably accelerated motio fro y^e [illegible] possession

wch ye falling Body suffer fro gravity in ye
1st Moment of time is not destroy'd in ye
2d therefore there is superadded to ye
impression [illegible] during ye 2d moment &
both those superadded to ye 3d; [illegible]
therefore it is perpetually accelerated & ye
equally in Equall times; for since ye
force of gravity acts every moment af-
ter ye same manner, it therefore commun-
icates an Equall velocity to Bodies in eq-
times. whence — — — —

9: 2dly ye Celerity wch ye Body hath acquired
at ye End of it fall is always as ye time
in wch ye Bodie has fallen; thus if a per-
:pendicular Line A B represent ye time Fig: 5:
of ye fall & ye Horizontall Lines D.E

wh: AD: BC (drawn horizontally AB)

fig5) represent ye velocities in any given point in ye time, shall be as AD: DE. &c as AE: AB: BC. Draw ye line AC & ye triangular surface ABC may represent ye space gone over in ye time

30. AB. Hence 3dly ye space passed over by a heavie body fro ye beginning of its fall are as ye squares of ye times in wch they are run thro. For since ye triangle ABC denotes ye space passed thro in ye time AB, ye triangle ADE: will denote ~~[illegible]~~ ye passed thro in ye time AD: now by ye Rules of Geometry ye triangles ABC. ADE are to each other as ye sides AB & AD: but ex Hypothesi these sides

represent ye times & those triangles ye spaces
therefore ye spaces passed over at diff.
times are as ye □res of those times to
each other, thus if a Body fall 16 feet
in a second, then in 10 seconds fall 10×10
=100 times 16 yt is 1600 feet. ———

31 Ifly If a Body descend from a certain height
with an accelerated motion & ye motion
uniformly wth ye last acquired velocity
it will in ye same time (as it spent in ye first blundering fool
of its fall, move fall thro a space double of
it moved thro in ye first fall. for if ye
triangle ABC denotes ye space run thro
in ye accelerated fall AB, its plain ye
rectangle ABCK may denote ye space
run thro in ye time AB wth ye velocity

5th ie as the 1st secd &c falling in a instant acquires [illegible] of Velocity; it is certain yt ye Space run thro in ye fall may be expressed by 0, 1, 2, 3, 4, 5 &c & ye Space described by ye Uniform motion by [illegible] &c ye the 1st Series viz 15 is half ye Sum of ye latter viz: 30.

32 ye Motion of a Body thrown up is retarded in ye same manner as yt of a falling body is accelerated; therefore 1st a Body thrown up is equally retarded in eql times.

2dly its ascent to its greatest height is perform'd in ye same time in wch if it had been falling it wd have acquird a velocity eql to yt wth wch it ascends; 3dly its velocities ascending & descending are eql to each other at all pts of ye Line.

supposing ym at all ye heights, ye
therefore ye Heights to wch Bodies wn thrown
up wth Diffnt velocities can attain are to
each other as ye squares of velocities
for since by ye foregoing rule ye Lines of
Ascent & descent in each projectile body
(velocity)
is ye same ye first ascending is eql to ye
last of descending & since ye Lines of de
:scent are as ye Vel. 2y or ye sqrs of ye last
Velocities descending it follows ye Lines
of Ascent are, as ye sqrs of ye last Velocities
ascending

II Of ye Motion of Projectiles.

33 under ye foregoing head we spoke of bodies
projected at right Angles to ye Horizon;

we come now to speak of Bodies projected in Lines parallel or obliq to ye Horizon; bodies moved in such directions & proceed on ad infinitū in a right Line were they not by force of gravity drawn tow:ds ye Earth, by wch means they are in every point of ye line of projectio accelerated tow:ds ye Earth, in such a manner as to describe ye Curve of a Parabola, fro ye properties of wch figure it is demonstrated, 1st yt ye greatest rando or Horizontall distance fro ye point of projection de- scribed by a projected body is wn ye direc -tion of a Body is elevated at 45 deg or ½ a right Angle 2dly yt ye 2 intermediate randoms

be taken at eq.ll distances from ye 45d one above ye other below they'll be eq.ll. 3dly ye greatest random is double ye greatest altitude of a perpendicular Projection, & they ye randoms of projectiles having ye same degrees of elevation but diff.t velocities are to one another as ye squares of their velocities; for ye randoms are as ye heights, to wch ye bodies thrown up wd ascend but these heights are (by sect. 31.) as ye squares of ye velocities.

III Of ye Descent of heavy Bodies on Inclined Plains. — —

34 If ye same or 2 eql bodies descend by ye force of gravity one along ye inclined plain AB ye other down ye perpendicular AC.

since each is impelled by an eq.l force

Since in ye of gravity ye Diff.t Intensities of two forces wch beat ye same space goes two inversly as ye space ... of ye body it is impelled along ye Right line AB is to yt by wch it fall thro AC as AC is to AB; whence a Body laid upon an Inclined plain loses part of its gravity & ye power required to sustain it must be to ye weight as AC ~~to AB~~.

35 since ye force wth wch a body is impelled along an inclined plain arises fro gravity, every thing yt has been sd concerning motions uniformly accelerated & hold good in motions along inclined planes

36 In Ord^r to know y^e time of y^e plaine AB w^{ch} y^e body pass^s over in y^e same time it w^d pass thro AC draw CG perpendicul^r AB & AG w^{ch} by y^e 8 prop. of y^e 6 Eucl. is y^e length of y^e plain AB w^{ch} be to y^e height AC as AC to AG.

37. Hence it is manifest y^t y^e velocities acquir'd in y^e same time by bodies falling perpendicularly & rolling on inclin'd planes are as y^e spaces run through.

38 If AC be made y^e Diam^r of a semicircle y^e point G w^{ch} falling in y^e periphery fr[om] All angles in a semicircle (as ACG, AHC,)

are right ones; therefore ye points ye Chords without any Inclination of ye Plane wd allways be in ye Periphery; whence it follows yt all ye Chords (as AG, AH.) are passd thro in ye same time yt ye Diamr AC is & consequently are all passd thro in eqll times.

3) The velocity acquired at B after ye descent thro AB is eqll to ye velocity acquired at C after ye descent thro AC; for after eqll times wn ye Bodies are at G & C, their velocities are in ye same ratio as ye forces by wch they are impelled, i.e. by Sect. 34. as AC to AB. wn ye Body descended [illegible] to B ye velocity

increases as ye time & ye velocity of ye 2d also to ye Velocity at B. as AC to AB; wherefore since ye Velocities in B & C have same propn to ye Velocity in G, they are as ye times

40 since ye Angle of Inclination makes no Diffe in ye velocity acquired at ye End of ye fall, whether ye fall be along an inclind plane or directly down; ye velocity of a body may run down over Planes differently inclind. or along a Curve (wch may be consid as an infinite No of planes diff inclind) & ye Velocity will always be ye same when ye heights are equall.

41 A Body yt has run down any inclined sur-
face either plain or Curve, wth certain
Velocity, will rise to ye same height along
another similar Surface wth ye same
Velocity & in ye same time it descended it:
as may easily be gathered from Sect: 31.
on wch principle depends ye Rules for
ye Vibration or oscillation of pendulums
to be treated of in ye next place.

Of the Vibration of Pendulums.

42 A Pendulum is either single or Compound.
a single Pendulum is a heavy Body
fastned to ye End of a string & moving freely ab:

y^e point (P) w^{ch} y^e String is fastned as at a Centre
y^e p^t is call'd y^e Centre of Suspension; y^e
Centre of Vibration or oscillatio in an orbi-
cular pendulum w^{ch} being y^e Centre of y^e body
in pendulums of other fig: is w^{ch} ben y^e
Centre of gravity: y^e distance between y^e
Centres of Vibratio & suspensio is call'd y^e
length of y^e pendula. and when Bar or any
Rigid inflexible body hung up & moves to & fro
moveable ab^t a Centre is call'd a compound
pendulu for reasons to be seen below.
43 We shall 1^{st} consid^r y^e Single pendulu y^e
pend:^m CA be drawn back to D & let go it
shall (by art. 41) oscillate for 2 D.A. spent the
& reach 2 C or D, & are equal & back again

fro E to A & yn to D ye times of ascent thro
A E sh'd be eq'll to ye times of descent thro A
(& each w'd be eq'll to ye times of descent thro EA
Fig. for p. 35) so yt ye pendulu' sh'd perpetually
vibrate in ye Arch DE but here we must sup-
pose ye body to meet w'th no opposition fro ye
medium it vibrates in: & to move w'thout friction
ab't ye center of suspension E: w'ch are ye two
2 impediments ye vibration of a pendulu' w'd be a
perpetuall motion; ye former inconvenience
may be pretty well removed by hanging ye
pendulu' in a vacuum; but ye latter can
never be removed entirely. fro ye former
pt. of ys section it follows.

44 Find, if ye time of an entire oscillation (i.e. there of ye
whole Ark DE & back againe) shall bee ye [illegible]
twice ye time of direct descent thro Bd;
for (by ye 34 Sect: bee ye same whether ye Pendulum
vibrate in ye Chord DE, or DE in ye Arches
DA. AE: & (by Sect 35) ye time of descent thro
Dd is eq[ual] to ye time of ascent thro Dd. there
fore ye time of one oscillatio must be ye double
time of 2 falls fro Bd. Q.E.D. againe if a
body falls fro Bd ~~[illegible]~~
~~[illegible]~~ in 2 minutes it will in twice
ye time (by Sect 27) fall thro 4 times Bd.
therefore ye time of one oscillatio is also
ye double ye time of direct descent thro 4
times

be 1 or three times y^e Length of y^e Pendulum

Ed.

45. Secondly, y^t y^e same time of oscillatio thro any 2 Chords or Arches of y^e same Circle whether greater or less shall be y^e same, y^e pendulum Vibrating quicker in larger & slower in small arcs as may be gather'd fro 35^th Section.

46. Thirdly, y^t in diff^t Circles, y^t is in pendulums of Diff^t Lengths, y^e times of oscillatio thro similar arches are in subduplicate proportio or as y^e Square Roots of Diam^rs or of y^e Length of y^e pendulums; for because y^e times of their descent are as y^e Square Roots of y^e Lines or spaces gone thro, & y^e time of an oscillatio is always double y^e time

of

direct descent thro ye Diamr of ye Circle
it follows yt in diffl Circles ye times
of oscillatio must also be as ye Square
Roots of ye radij taken 4 times, or as
ye Square Roots of ye Length of ye
Pendulums; & ye length of one entire
Oscillatio may continue still double
the time of direct descent (vid sect 29,
44) thus if ye Length of 1 pendulum
be 16 feet, of ye other 9, ye times
of their oscillations wil be to one
another as ye Sqr Roots of those
quantities ye is as 4 to 3; so yt for instance
if ye time of one entire oscillation
of ye longer be 4" ye time of ye other
wil be 3".

17 The smaller ye ~~[illegible]~~ arches of a pendulum ye more
equall ye vibrations be to one another
& in exceeding small arches ye vibrations
are performed in ye same time as if ye pendu-
-lum did swing in vacuo; Huygens has
shown that ye vibrations of ye pendulum oscillating
in ye arch of a Cycloid instead of a
Circle, ye 3 Rules above given are
held true in larger arches also. And
since ye Length of a pendulum oscill-
-ating seconds in a Cycloid of [illegible]
very nearly ye same in ye smallest arches
of a Circle is found to be 39.2 Inches.

48 A Compound pendulum Oscillates quicker
yn ye single one of ye same length, for
ye Upper parts, like so many distinct
pendulums endeavour to oscillate
according to their respective distances
from ye point of suspension & by yt means
ye Motion of ye whole Pendulum is acce-
-lerated; ye Centre of oscillation in ye
Compound Pendulum is a point taken
$\frac{1}{3}$ of ye length of ye Pendulum from ye lower
end; for a single Pendulum is found
to oscillate as fast as a Compound
one $\frac{1}{3}$ longer.

4) Pendulums are found to oscillate slower near ye Equator yn near ye Poles for ye force of gravity on wch oscillatory motion depends is less under ye line yn near ye Poles, by reason of ye greatest length of ye Equatoreall Diamr & ye greatest Centrifugall force in those parts of ye Earth. we shall conclude ye head wth a few problems showing ye use of Pendulums.

5. Prob. 1st To find ye length of a pendulum yt shall make any No of vibrations (as 50) in a minute. Since ye lengths of ye Pendulums are (by Prob 4) as ye 2ds of ye times of their vibrations,

A pendulu vibrating seconds or 60 times in a minute is found to be 39.2 Inches long. Say, as ye Sqre of 80 is to ye Sqre of 60 so is 39.2 Inches: to ye pendulums length desired wch will be found to be 50,4.

Prob. 2d. ye length of a pendulu being given to find ye No. of vibrations in a Minute. This is ye reverse of ye former Probe: therefore as ye given Length (suppose 56.4 Inches) is to ye length of ye standard pendulu swinging seconds viz: 39.2; so is ye Sqre of ye vibrations

of ye Hand ye pendulu long ye Line of ye
Vibrations sought, ye Clock Hand. thus
viz 60 :: 39. 2 = 3600 : 2500 : & ye Square
Root of 2500 : = 50 [illegible] ye No of
Vibrations sought. for the [illegible]
only divide 14 200 by ye given length
& ye Quotient will be ye Square of ye vibra
-tions. thus if for greater accuracy you
wd count ye beats of a Clock or watch
(whose motions may perhaps be une:
qual) measure ye duration of an Eclipse
write down ye No of ye Vibrations made
during ye Eclipse, & ye exact length

of ye Pendulum in Inches & Decimal
pts of Inches; & yn divide 141120[0]
by ye penduluma length & ye Quotient
will be a No whose Square Root is ye
No of Vibrations made in a minute
& yt therefore of all ye Vibrations
During ye Eclipse being divided by
60 ye Quot: will be ye no of minutes ye
Eclipse lasted.

12. Prob: 3d. to find ye length of any thing
& height hanging stil only by ye
Vibrations of a Pendulum. As for
instance set ye string & weight a swinging,

ye pendulū of any known length (sup
pose a ft) a vibrating & after ye pen
-dulū has made a competent Nor
of vibrations (suppose 50 or 60)
let both be stopd again at ye same
instant this done ye No of vibrations
of each being known, suppose ye
Pend: vibrated 60 times & ye string
& weight 10 times, since ye lengths of
Pendulums are to each other as ye squares
of ye vibrations divide 3600 (ye sq.
of 60) by ye sq. of 10 & ye quotient
wch is 36, therefore ye length of ye
string wch is 36 times ye length of ye
pendulū or 36 ft.

* Or the distance of any ship, Fort, Thundercloud by accuratly observing the time between seeing the Flash, and hearing the report of any Gun or Clap of Thunder.

thus may be found ye height of any Steeple
by means of a Branch Candlestick hanging
fro ye Roof if to ye Length of ye Rope of ye
Candlestick (found by ye Rule) ye add ye
distance of ye Centre of ye Candlestick from
ye ground.

n°3. According to these Principles & experimts
on Pendulums it will not be difficult to estimate
nearly ye Depth of a Draw well by ye fall of a
Stone fro ye Mouth.* there remains only
to apply ye 2d Law of Nature to ye Rules of

[illegible]

Of Compound motion arising fro sliding Forces.

54 If ye Body A is at ye same time impelled by 2
forces one in ye direction & wth ye Velocity
A B ye other in ye direction & wth ye Velocity
A C lo: in ye motion yt must arise fro these
forces ~~[illegible]~~ compleat ye parallelogram
Fig: A B C D & ye Diagonal A D will be ye direction
in wch ye body wil move, for let ye Body A be
suppos'd wth ye force & Velocity to describe
ye Line A C & let ye whole Line be carried along
always parallel to itself in ye direction & wth ye
Velocity A B wn ye Line is come to ye H, ye body
wl be at G. draw a parallel to A B & yn it
~~[illegible]~~ form ye little parallelogram a G,
624. wch by ye Rules of Geometry wl be similar to ye
parallelogram C B & consequently by ye same
Rules by ye wch be standing Line A D therefore
yt Line wll be pass'd over &c.

Or: the Line AB wd be passed over in ye same time yt ye Line AC or AB wd have been passed over wth only ye velocity AC or AB.

151 Hence it appears yt any motion whatever tho in it self never so simple may be considd as compounded of more motions; for if a moving body wth a force AD passes over ye Line AD ye motion is ye same as if it had been Originally impressed by 2 forces AB & AC hence we prove.

152 If a Swimming obliquely on ye line or place DE ye Magnitude of ye oblique stroke wd be to ye Magnitude of ye perpendicular Stroke impinged wth ye same velocity as AD the Sign of the Angle of incidence to AC the Radius for ye oblique motion AE be resolved into 2 motions along AD & AB:

line AB is parallel to DC if y^e body moved in AB
only it w^d never have impinged on DC at all;
9. therefore DC is not affected w^th y^t part of y^e
at all
motion, y^e force therefore w^th w^ch y^e body impinges
on y^e obstacle is as y^e Line AD therefore
the whole force of y^e Body in y^e Right line
AC is to y^t force by w^ch it impinges on y^e
obstacle as AC is to AD, but had y^e body
impinged ~~[illegible]~~ perpendicularly w^th y^e
whole force AC y^e greatness of y^e stroke w^d
have been as AC for y^e whole motion had been
destroyed by y^e obstacle: wherefore y^e magnitude
of y^e obliq3 stroke w^ll be to y^t of y^e perpendicular
stroke w^th y^e same velocity as AD to AC.

57. If a body perfectly elastick impinges obliq3ly
on a firm obstacle, y^e Angle of Reflexion w^d
Fig. 10. be eq^l to y^e Angle of incidence: for let y^e obliq3
motion of AB or y^e Elastick body A impinging
in y^t direction on y^e firm obstacle DE be
Resolved into

= others AE & AB, by y^e former Section y^e
impinging force is only y^t w^{ch} acts in the
Direction AD: erect BF = ED parallel
to AD: Draw BE eq^l to DB & AE & comp
-leat the Rectangle FE: w^{ch} w^{ll} be similar &
eq^{ll} to DE now since the motion along AE
is not destroyed by the stroke after the
impulse in B that force remaining
in the Body to move in y^e direction
BE w^{ll} be as AE or BF but from the
Nature of Elasticity, a Body impinging
w^{th} EB in y^e direction EB is reflected
w^{th} y^e same force according to y^e same directions
so y^t those forw^{ds} & motions w^{ll} be compounded
of BE & BF, where (Axiom 4) it w^{ll} describe
y^e Line BC but it's plain from y^e construction

of ye figure may be geometrically prov'd ye Angle of reflexion is equal to ye Angle of incidence ABD.

Theorems from ye 3d Law of Nature.

58 here we shall consider ye several ways by wch bodies act on each other as attraction & repulsion & lastly impact, and of ye latter we shall demonstrate some certain Theorems relating 1st to ye Congress of hard bodies, 2dly to ye Congress of Elastick Bodies. ——

Of ye Action of Bodies upon one another.

59 tho all matter be of its own Nature perfectly sluggish & unactive, 'tis yet observed yt ye whole Creation is govern'd far & wide, by certain act-ive powers & principles of Nature which are of such force as may produce something
some unaccountable principle

I mean any force by wch bodies are carried towds or
from one another according to certain determi
:nate laws, generally call'd ye Laws of Att
:raction & Repulsion, these are some
of ye Ancients call'd occult Qualities & were
thought to be ye result of certain Mecha
:nicall principles, but are now esteem'd
wth more reason thought to be ye Gen:
:erall Laws of Nature establish'd by
God himself at ye Creation, wth such &
such Limits & circumstances; yt these prin
:ciples are wholly immechanicall & indepen
:dent of matter, we thus prove, since
matter is of it self indiff.t to motion or
rest: it follows yt motion is not an abso
:lute necessary effect of matter & since
these principles are

nothing but certain species of motion; neither do they belong to matter as such.

60 There are generally reckon'd 2 sorts of attr-actions Gravitation & Cohesion we shall first treat of attraction of gravitation but since we have had such freq.t occasion to speak of gravitation before, we shall now do little else, but give a short acc.t of the diff.t opinions w.ch Phylosophers of Diff.t Ages have had. — — —

Of Gravitation.

61 Phylosophy has met w.th diff.t impediments in diff.t Ages so there are & have been vari-ous sentim.ts ab.t y.e weight & gener.l effects of matter;

62 It is to be thought y.t all Earthly Bodies have a natural tendency tow.ds y.e Earth as to [illegible] perpendicularly

but if they be not sufficiently forced of
them in ye [illegible]
absolute levity;

63 Copernicus tho^u^t it to be an innate
principle in all ye p^ts^ of matter, w^ch^
when they are separated from their whole
[illegible] thither again
ye nearest way in right lines.
but ye is only to tell us in other words
that heavie bodies gravitate or
descend; but gives us not ye least
idea of ye cause of gravity.

6[illegible] Gassendus, Kepler & many others
have thought ye earth to be a great magnet
continually [illegible] ye [illegible]
[illegible]

wch lay hold on all bodies & draw ym down to the Earth; but were it so, it is manifest yt a plain thin body placed parallel to ye Horizon wd be heavier in yt posture yn wn placed perpendicular, & bodies a[illegible] wn reduced to powder, ought to weigh more yn whole; by having then more surfaces though to be more exposed to ye Effluvia, whereas as before we Imagine ye Effluvia should act on ye internal pts as efficaciously as on ye External.

op. Des Cartes supposes ye Particles of his Etherial matter being reflected from ye surface of the Earth & consequently ascending upwards,

to bring down others. yt may be proved
to be false from Hydrostatical princi-
-ples; besides it implies a kind of
contradiction yt bodies should be forced down
(since) by a continuall flux of the
matter tending upwards; and acting
on all parts uniformly & equally. - - -
3d Des Cartes & some others think ye diur-
-nal rotation of ye Earth about its axis
is ye Cause of ye descent of heavy
bodies; but it's certain yt ye centr.
of bodies moving in circles do always
endeavour to recede from ye axe of motion.
4ly others mistaking ye cause for ye effect
attribute ye descent of heavy bodies to ye
pressure of ye atmosphere;

wch is easily computed from bodies fall
ing in vacuo freer yn in open Air,
therefore ye true cause of gravity
can be neither yt ye mentioned above.

Sect. 59. — — — — —

63. but before we leave ye Head we must
observe yt ye force of gravitation is
greatest at or near ye surface of ye Earth, for at all
distances above ye Surface it decreases
as ye Squares of ye distances increase at all
distances between ye Surface & Centre
it diminishes in a direct simple pro
portion of ye contrary actions of ye upper
parts so yt at the Centre there's no attraction
at all; for ye attractive forces coming
from all parts of ye Earth in equal Circles,

and in contrary directions counterpoise
and destroy each others attraction;
wherefore if there is in ye middle of
a hollow concave sphere, Bodies
placed in ye sphere wd have no weight
since they wd be eqly attracted in all di-
rections, by ye particles composing ye
sphere; tis true ye attraction of any
spherical body at distances beyond
its surface may be considd as proceeding
from ye centre & point of ye sphere; but this
wd not hold good within its surface; for
there not ye centre yt attracts but only ye united
pts of ye body wch constitute ye attraction of
Cohesion.

7) The smaller particles of matter attract each other wth a force very Diff. from yt of gravity; for whereas ye force of gravity acts at all distances in a reciprocall proportion of ye Qres of their Distances, & direct proportion of ye quantities of matter; ys sort of attraction is not sensible but in immediate contact, or at least at distances infinitely small; therefore it increases more yn ye Qres of ye Distances decrease (perhaps it may increase in a reciprocall proportion of ye cubes of ye Distances or in a reciprocall proportn of some higher power) & at some determinate distance it intirely stops.

by reason yt ye attractive distance is so very
smal, ye force appears to be rather as the
Quantity of surface yn as the quantity of
matter; thus in magneticall attraction
a smal Loadstone has more efficacy
(pro rata) yn a great one; ye effects of yt
sort of attraction are visible in ye globu-
-lar drops of Rain or fluids: ye ebullitions
fermentations & Chrystallizations of ye
Chimists, ye ascent of Liquors in Capillary
tubes & especially in ye Cohesion in ye parts
of matter not fluid: according to ye diff.
degrees of ye cohesion bodies are Hard
soft or fluid: such particles whose mutual
attractions

exceed their ~~much~~ weight are sd to form a
hard body, those, whose mutual attractions
exceed their weight but in moderate degree
compose a soft body, those ye attraction is
but little greatr yn yr weight a fluid is
constituted as hath been before yt kind of
attraction acts only at indeterminately small
distances & yt there, but it is farther observed
yt where ye force of attn end. immediately
begins yt of Repulsion. above we shd
speak of Elasticity— —

92 The force of Repulsion increases as ye distance
of ye repelling particles decreases & yt ye
ye force of attraction is with ye [illegible] of attrac-
tion,

ye greater is ye repulsive force beyond it.
ye Effect of ye force is evidt in Oyl & watr
put together; for it is for hence yt we
find difficult to make ye pts of Oyl or
greace come so close to ye pts of water
as to stick together; hence also may
be seen ye reason why Quicksilver
in ye Barometr rises wth a convex
surface while liquors rise in glass
tubes wth a concave surface; why dust
& sand swim upon water & flies walk
upon it without wetting their feet; why
ye pts of salt, after they are separated
by ye attraction of ye water endeavour
to recede from each other as far as

posite till they all stand at ye distan-
-ces, communicating an equal Degree of
hotness to all pts of ye Water. —

41 This repulsive force seems also to be ye
cause of Elasticity in most bodies; for
when an Elastick body is compressed
all its pores being immediately con-
-tracted, many particles, wch were
at some distance before, are now
brought nearer together, within
ye sphere of each others repulsion
by means of wch as soon as ye com-
-pressive force is gone, they are
thrown back again into their
former situation, ye repulsive
force growing stronger

as ye particles are forced closer to
each other; we may hence see why ye
Elasticity of Bodies is increased by
hammering & why bodies, whose pores
are very large may admit of compress-
-ion without much Elasticity, wch [illegible]
constitution is ye [illegible] presence [illegible]
-pression. there is no true properly
Elastick ~~[illegible]~~ Elastick Bodies may be
conceiv'd as consisting of small
threads or fibres laid. —
42 together so as to compose an Elastick
Body; wherefore ye Treatise may examine
ye Nature of Elasticity in ye present
improveable we speak only of
musical

Elastick & metalline strings. if
a string be strain'd & immediately
let go again it w^th a very great
force returns to its former situatiō
& having requir'd a degree of Elas-
-ticity it w^ld be carried beyond it &
y^n back again, so from Elastick y^ir
being once stretch'd, it w^ll thence
forth vibrate like a pendulum,

Consequents ————

43. 1st It shall perform all its vibrations
greater & small in y^e same time.

44. 2^do y^t y^e 2 Dra.. y^e times of y^e vibrations
~~[illegible]~~ of 2 strings contain-
-ing eq^ll quantities of matter but having
different degrees of tension,

wch be to one another inversly *
as ye straining forces.

48. 3dly Tho in pendulums ye quantities
of matter make no difference
in ye times of ye vibrations, yet
in vibrating strings ye times of
vibration are proportional
to ye quantities of matter contain'd
in those strings; for wch their
strings are but equally strain-
ing forces shall be eql. commun.
ye velocities reciprocally as ye
quantity of matter & ye times reci-
procally as ye velocities i.e. ye times
wch be directly as ye quantity of matter

46: 4thly in strings of eqll Diamrs but unequal tension ye times shd be as ye 2d [illegible]
if ye lengths are eqll ye times shd be as ye diamrs.

47. 5thly ye times of ye vibrations of any strings of ye same kind are to each other in a ratio compounded of ye inverse Ratios of ye 2d Roots of ye straining forces & of ye direct Ratios of ye Lengths & ye Diamrs, wherefore in ordr to compare ye times of ye vibrations of any 2 strings multiply ye Diamr by its length & divide ye product by ye 2d Roots of ye straining forces ye Sd done ye Quotients will [illegible]

one another as y^e times of y^e vi-
-brations.

48 having thus premis'd concerning y^e nature & Laws of Elasticity w^ch was very necessary to be premis'd in ord^r to a true stating of y^e Laws of y^e Communication of motion w^ch c^d not be done w^thout distinguishing between hard & elastick bodies)

we come now to treat of y^e congress of bodies as well elastick as hard; & first of y^e Congress of hard bodies or any bodies not Elastick.

49. In y^e Congress of hard bodies or Elastick y^e stroke is proportionable to y^e Relative Velocity.

NB The Laws of percussion both of Bodies not Elastick and those y^t are Elastick; easily follow this Proposition.

The quantity of Motion in Bodies, which is the sum of of their motions, if tending to the same or or a different part, if they tend to contrary parts, it is not changed by their actions upon each other. Vid: Princ: L1 · Cor 3 ad Leg. Nat.

See the Nature of Elasticity explained in Keils Law: attr: Th: 12 —

ye relative velocity known of the
wch one body is carried towards another
or wth wch bodies are separated
wn ye motions are in ye same di-
rections, is ye diffce of ye Velocities
wn in contrary directions tis ye
Sum of ye Velocity. If any body strikes
agt another by ye 3rd Law of Nature
it loses just so much motion as it
communicates to ye body it strikes
agt. Upon wch grand principle depend
all ye Laws of ye communication of motion
wch in Bodies not Elastick may be
reduced to these 3 following cases.

80 If a moving body impinges on ano:ther at rest both ye bodies wd move to:gether in ye same direction as ye 1st motion but slower; for ye quantity of motion wd be ye same in ye 2 bodies after ye stroke as in ye single one before it.

81: the former part of ye proposition is a Necessary consequence of ye 2d Law of nature & ye latter does as necessarily follow from ye 2d Law. for all ye motion wch ye 1st body loses by impact is trans ferr'd to ye 2d. wherefore if ye Mass of ye first body be multiplyed

into its velocity ye product divided by ye Mass of both bodies ye Quotient will be ye common velocity after ye stroke: if ye bodies are eql $\frac{1}{2}$ of ye motion will be communicated.

82. If one body strikes on another yt moves ye same way but slower they will both move on in ye same direction as before; & ye quantity of motion after ye Congress will be ye same as before.

83: all ye theories follows fro ye first Case; if therefore ye quant of motion

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the 2 bodies be collected into 1 sum (by sect 4) & yt divided by ye Mass of both bodies ye Quot.t wd be ye Celerity of ye bodies after the Congress; if ye 2 bodies be eqal ye Common velocity after ye stroke wd be eql to ½ ye Sum of ye Velocities before it.

84. 11. If 2 bodies moving contrarwise wth Diff.t Velocities strike each other after ye Congress, they wd both conti-nue their motion together in ye same di-rection wth ye greatest motio, accordg ye quantity of motio after ye Congress wd be eql to ye Diff. of motio before it.

55. The former part of ye proposition may be proved thus: ye greater motion must needs overpower ye less; therefore by ye 2d Law of nature ye bodies must be carried together in ye same way in wch ye motion is directed; & since ye body wch has a less quantity of motion is carried in ye same line (but in a contrary direction) as before ye stroke, yt yt may be effected it is required yt by ye action of one body, ye whole motion be stopped, & in ye other wch cannot be done unless yt body by reactio loses an equall quantity of motion; therefore after ye stroke there remains only ye differe

of ye Motions, wch proves ye 2d pt. of ye proposition:
to determine ye Velocity of both bodies after
ye Congress, let ye momenta of each body be
found (by sect.) & ye Diff. of ye Momenta be
divided by ye Mass of both bodies & ye Quotient
will be ye Celerity requir'd.

80. Hence it follows yt if 2 bodies move to each
other wth equal momenta ye whole motion of ym
will be destroyed at their congress: & yt if a
moving body strikes upon an immoveable
obstacle its whole motion will be destroy'd
by ye stroke; in all these cases ye impinging
bodies are supposed unelastical & ye
impact direct & not oblique. — —

Of ye Congress of Elastick Bodies.

84. We shall here only consider ye Congress of such
bodies as are perfectly Elastick;

i.e. such as return to their first figure wth ye same force yt they are compress'd: in wch case ye Stroke arising fro ye restitutio of its spring is eqll to ye Stroke it compresses; whence it follows yt in ye Congress of 2 Elastick bodies & ye whole force of Elasticity exerted at ye restitutio of both ye Springs is double ye quantity of ye Stroke for its ye result of 2 Elastick forces, in contrary directions, each of wch is eqll to ye quanty of ye Stroke therefore ye Change of motio produc'd in each body by ye Stroke is double to that wch ye Stroke by ye same force wd have produc'd in bodies void of Elasticity: X in ye same ordr yt we have determin'd ye Changes in ye foregoing Chapter; we shall

determining it itself also wth respect to Elast. Bodies Impinging: where we must observe ye following Rules. — —

88. If 2 Bodies not Elast. impinge on eachother & one of ym acquires a Certain quantity of Motio, it wd acquire twice as much if ye Bodies where Elas.t, & ye Double quantity is to be added to ye first motio to determine ye motio after ye Stroke. — — —

89. If 2 hard bodies not Elast. impinging on eachother wrong ym loses a certain quant.t of motio it wd lose twice as much if ye bodies were Elas.t & ye Double quant.t is to be subt.t fro ye first motio to determine ye motion after ye Stroke. — — — — —

90. Examp: 1st. Suppose 2 Elast. Bodies as A & B

Let A whose velocity is 9 & Mass 2 impinge
upon B at rest whose Mass is 1 & since 'tis found
after ye Stroke B moves wth ye Velocity 12
& A continues its motion wth ye Velocity 3
for if ye Bodies were perfect Elastic ye Velocity
of both after ye Stroke wd be (by Rule 1st) 6
so yt B, wch was before at Rest, wd gain 6
Degrees of velocity, but since ye Bodies are
perfectly Elastic, B must (by Rule 2d) gain 6 + 6 = 12
Degrees of velocity & A having 3 must
(by ye 2d Rule) loose 6 wch subtracted
from ye former velocity leaves 3.

91. Examp. 2d. Let A whose Mass is 2 & velo-
-city 8 impinge on B (moving ye
same direction as A) whose Mass is 1 & Velo-
-city 5; after ye Congress (by Rule 2d) ye
Body B will move wth ye Velocity 9 & A
wth ye Velocity 6;

Bodies

... if ye Bodies were not Elast., after ~~...~~ 2 Degrees of velocity wch [illegible] must be doubled & added to ye first veloc. wch makes 9; & so where 1 degree of velocity wch must here (by rule 2) be doubled, & so subtracted from ye former 9 leaves 8; & so there will be 16.

92. 3. If a body looses all its own motion & acquires a motion ye contrary way, that 2 motions must be added together in order to find ye Motion lost. or ye Quant. wch is took out (by Rule 2) because ye Quant. of motion before ye stroke. from wch it must be subt.; ye whole Quant. of motion is destroyed by it. & ye rest then being subtracted from;

w^d give y^e motio y^e contrary way. — —

93. Example 4^th. suppose 2 Non. Bodies A & B, both w^th y^e Velocity 12, they singly meet, & suppose that B 3 times as heavy as A, y^e body A w^d return w^th y^e velocity 6 ; for were y^e bodies not elast. they w^d move w^th y^e velocity 3 ; so y^t A w^d have lost 9 ; & rule 2^d it must lose 18, w^ch ought to be subtracted fro y^e former velo: 12, but since y^t can't be done y^e must y^e rule 3^d take the diff^ce between 18 & 12 = 6 there-fore y^e velo. y^e contrary way w^d be 6. from these rules may be deduc^d these following Laws of y^e Congress of perfectly Elast^c Bodies.

case first 94 If an Elast^t body overtake another of eq^l mass. they w^d continue their motion in y^e same directio but w^th interchanged velocities.

95. let AB be ye Velocity of one Body & DE ye Velo.y
of ye other, suppose AE in ye Ratio of CB to CD
if ye Bodies were not Elas.t AE w.d be ye direct
their velocity after ye Impact, so ye Velocity
DE increases by Quan.t ED, but since the
bodies are Elas.t it must (by Rule 2) be
doubled becoming BE. Again were ye
Bodies not Elas.t ye Velocity AD w.d be
diminished by ye Quan.t CD. but by
reason of their Elas.t it must (by rule 2)
be diminished by BD, double ye Quan.t
becoming thereby AB, so yt ye Velo.s AD
DE w.d be interchanged, AD becoming
AB or DE & DE becoming BE or AD.
96. This may be farther illustrated by numbers

let ye Velocity of A one Body be 8 & of B ye other Body 6. after ye Congress ye Velty of A wd be 6 & of B 8, for they are Elast; since their Masses are ye same their common velocity wd be (p. 81. 52.) ye half of ye body 8 to 6. but since they are Elast. A must lose twice ye mean Diver. & have move with ye velocity 6. the Body B likewise were it not Elast. wd have gained 1 but by rules it must gaine 2 & so move with ye Velocity 8. ye Body A ywd change its velocity 8 for ye Veloc. of B, & ye Body B its velocity 6 for yt of A 8.

97. Coro. If 2 eql. Elast Bodies meet each other with uneql. veloc. they shall fly off from each other in contrary directions & interchang Velocities.

it shall rebound wth ye same force it impingd wth whether ye Obstacle be Elastick or not, for if it be not Elastick its reaction agst double ye Quantity of Elasticity wch produces ye same Effect as a single quantity of Elasticity in each body acting in contrary directions. 4thly when a small Elast. body strikes on another greatr Elast. body it acquires a greatr Quantity of motion yn ye small one had before ye stroke; for yt gaind by ye great one is double wt ye little one wd loose were ye bodies not Elastick, but in yt case ye little one wd loose more yn

half its motion, (by Sect. 80.)

98\. See this Consideration is also prov Sect. 84 may be seen y^e folly of y^e Cartesian tenet of there is always y^e same Quantity of Motion in y^e world: for tho y^e Summe of motion of Bodies after Collision does often remain y^e same as before it, yet it is often diminished & often in-creased. all these Rules above mentioned are experimentally proved by Graves=ande in his Chapter of y^e Congress of Elastick Bodies. Fro w^ch Author is tis (?) y^e foregoing Chapter is Chiefly extracted. — —

19. Let BC be ye Velocity of one Body, & D of ye Other; bisect ye Diff. BD in E: & take BA = DE. after ye Congress, were ye Bodies not Elast., ye Veloct. of Each of ym wd be ye same side wth BC (p Sect. 52) so yt ye first Body wd have Lost ye Pt of its Veloct. CE & ye other all its former Veloct. CD and acqd. BE in a Contrary directn; so yt ye whole quant. Lost is CE (by Sect. 52) but since ye Bodies are Elast., ye quant. is to be doubled (by reason) therefore it wd become AE: ye Diff. of ye Velocity wth ye velocity of Each Body does in Each Body

* It shall rebound with the same force it impinged with whether the object be Elastick or not, for if it be not Elastick, it's reaction against double the quantity of Elasticity will produce the same effect as a single quantity of Elasticity in each Body acting in contrary directions. 4thly when a small Elastick Body strikes on another greater Elastick Body at rest ye great Body requires a greater quantity of motion than the small one had before the stroke; for that gained by the great one is double to what the little one would lose, were the Bodies not Elastick. but in that case the little one would lose more than half it's motion C

gives a Velocity the contrary way (by hypothesis) but of Diff[eren]t for BC is AB & for ED is DA but DA is = AB & BC = AD, therefore after the Congress, the veloc[i]t[ie]s w[i]ll be inter-changed BC becoming ED & ED becoming BE.

Hence it follows 1st that if 2 equall Elast[ic] Bodies move tow[ar]ds each other w[i]th equall veloc[i]t[y] they sh[a]ll also rebound w[i]th equall Velocities. 2d that if an Elast[ic] Body impinges on another equall to it at rest, it sh[a]ll communi-cate all its veloc[i]t[y] to it & remain at rest its self in its place. 3dly that if an Elast[ic] Body impinges on an immo-veable Obstacle +

Part 3d

The Laws of Nature Applied to ye
System of ye World. How ye Sun & fixed
Stars are retain'd in their Place. ——

101 As where ye attraction of Cohesion
Ends there begins a repellent force so
'tis thought by some yt ye force of gra-
-vitation may at some determinate
distance be also turn'd into a repelling
or Centrifugal force; an oppinion very
suitable to ye wonderfull regularity &
uniformity observ'd to run thro all ye
works of Nature; If therefore ye deter-
minate distance be conceiv'd as ye
Limits of ye respective Systems

of any Sun or fix'd Star, y^t are not sufficient to keep y^m in their proper places, i.e. at due distances from one another See page the 95 * ——

How y^e Planets are retain'd in their orbits.

102 ~~to~~ say nothing of y^e Solid orbs & vortices of y^e Ancients, by w^{ch} they suppos'd y^e Planets to be whirl'd round in their orbits, since they have already been confuted in sever^{ll} places, we shall come directly to y^e true reasons of y^e Modern Philosophers & these are their Centrifugall & Centri-petall Forces; by y^e former of w^{ch} the bodys endeavour to fly off from y^e Centre

round wch they revolve, ye latter to
approach towds it, but by ye 1st Law
of Nature ye Motion arising from these
2 forces must be performed in Curves
returning into yemselves. —

113: But farther. it has been demonstrated
by Sr Isaac Newton, yt if a planet re-
-volving in an orbit describes eqll
Areas in eqll times abt any point wth
in yt orbit, yn ye planet tends towds yt
point as to a Centre; & it appears yt
ye most accurate Astronomical
Observations yt ye primary Planets
describe eqll Areas abt ye Sun

& ye Secundary planets abt their res-
-pective Primaries. whence it appears
yt ye Sun is ye Centra virtue of ym &
their respective secundaries. as
also yt ye gravitatio by wch ye Planets
are kept in their orbits is of ye same
Nature wth yt by wch heavy bodies near
ye Earths surface tend to its centre,
yt is demonstrated, by Sr Isaak Newton
to be true wth respect to ye moon. viz: yt
ye force by wch ye Moon is kept in her
orbit if continued down to ye Earth
is Equivalent to yt force by wch all bodies are

to ye Centre of ye Earth & consequently ye
same; for were they diff. forces, bodies
wd fall with diff.t velocities pro ut they
denser. yt ye rest of ye planets are retaind
in their orbits by ye same force is only
to be proved pro analogy; for they
are bodies like ye moon & moved in
Elliptical orbits like her.

104. In ordr to undrstand how a planet by
ye same law can be made to move
faster in its perihelion; we must
observe first yt if gravity acts in
ye same direction on wch ye body
moves it wd accelerate it; secondly
yt if it acts in a contrary direction

it w.d retard its motion, 3.dly if ye
force of gravity acts at right angles
wth ye direction of ye body it w.d neither
accelerate nor retard it, being yn
exactly between ye same & a con-
trary direction & consequently
accelerates & retards in ye same
measure; so yt a planet coming
down from its Aphelion is continu
ally accelerated in ye same manner
as heavy bodies are accelerated
in their fall, ye direction of ye force
of gravity making an acute
vid: Rowe's mec: 101. Angle wth ye direction of ye planet.
Again for a contrary reason a

Planet ascending frō its Perihelio to its aphelion is continually retarded till it comes to its Aphelio, wⁿ it again begins to be accelerated, pretty much like yᵉ retardation of heavy Bodies wⁿ they are thrown up perpendicular to yᵉ Surface of yᵉ Earth. N.B. yᵉ direction of a planet is determined by a tangent drawn frō yᵉ pᵗ of yᵉ orbit in wᶜʰ yᵉ planet is. This being premis'd we come now to answʳ some objectiōs agᵗ yᵉ foregoing Principles. Some objections answᵉʳᵈ.

116: The first Objectiō is frō yᵉ Curvature of yᵉ Orbits of yᵉ Planets being

y^e same in Perihelio as in Aphelio.
For say they, Gravity is y^e only cause
of y^e Curvature of y^e Planetary orbits
since if they were not restrained by
y^e force of gravity they w^d by y^e first
Law of Nature move on in right
lines in infinitum; therefore since
y^e Effect is always proportionable
to y^e Cause y^e Curvature of y^e orbits
ought to be greater in Perihelio
where y^e force of gravity is greatest
but experience shews it is not so,
therefore y^e Planets are not retained
in their orbits by Gravity.

* That Hypothesis, of the attraction of Gravitation being turned into a repellent force, at the limits of the Solar System, is groundless, and appears from hence, that our Comets are retained in their Orbits by their gravity to the Sun, when they are so far off as to become invisable, whereas Comets belonging to other stars, tho' they come ~~so~~ near as to be visable to us, are yet retained in their Orbits, by the attraction of their Central Stars; this is an argument that the attractive force of our Sun, reaches the place to which the attraction of other stars extend to. If we would give ourselves liberty of thinking, wee might perhaps with as much reason suppose, that each Central star has an attraction to their respective planets, and Comets but a repulsion to those of others (as the Load-stone only attracts Iron, amber only straws) but true philosophy has suffered too much from those who would make the Reveries of their own Brain pass for the Laws of Natur, and thought an ingenious Hypothesis, an un=doubted explication of all the Phœnomena of Nature.

104: It may be answ^d^ y^t^ y^e^ Curvature of y^e^ Orbit of a planet does not depend upon gravity alone, but upon gravity & y^e^ planets velocity together & is as y^e^ gravity directly & y^e^ velocity reciprocally: so y^t^ if where y^e^ gravity is greater y^e^ velocity be greater also or if y^e^ gravity is less as y^e^ velocity be less also y^e^ curvature must remain y^e^ same; w^ch^ is exactly our case.

108: 2^d^ Obj^n^ answ^d^. 'Tis another difficulty to conceive how a planet after it has described its Perihelion can by y^e^ same law be made to ascend to its Aphelion again.

for it may be objected yt since ye force of
gravity is encreased every minute,
whilst ye planet approaches to its peri-
-helion, it ought not therefore to revolve
in a curve returning into itself but
rather describe a spiral line round ye sun,
continually going nearer & nearer, so yt in length
of time it wd be drawn so as to fall into ye
body of ye sun. This argument is answered Mathema-
tically by newton.
109. In answr to ye objection we must premise
yt ye descent of a planet towd ye sun & its as-
cent from ye sun does not immediately de-
pend on ye quantity of ye Centripete

or Velocity of y^e planet but upon y^e Angle, wch y^e present direction of y^e planet makes wth y^e line drawn frō y^e planet to y^e sun. 2dly wn a planet moves in any given directiō, y^e vis projectilis may be so strong, or y^e vis centripeta so languid as to suffer y^e Angle wch y^e directio of y^e planet makes wth a line drawn frō y^e planet to y^e sun conist-antly to encrease or on y^e other hand y^e vis centripeta may be so strong or y^e vis projectilis so weak y^t y^e Angle wch y^e direction of y^e planet makes wth a line drawn frō y^e planet to y^e sun

may be constantly diminish'd. ——

110\. 3^dly^ The vis centripeta & vis projectilis may be so temper'd w^th^ one another, as y^t^ y^e^ Angle w^ch^ y^e^ Directi\u0304o of y^e^ planet makes w^th^ a Line drawn to y^e^ Sun may for a while be continually invariable.

111: These things premis'd, Since y^t^ a planet does not come nearer to or go farther of fro y^e^ Sun as its vis centripeta is great^r^ or less, but as its directi\u0304o makes an acute or obtuse angle w^th^ a Line drawn to y^e^ Sun. Suppose a planet comes down fro its Aphelion to its Perihelion;

it has acquir'd ye great vis projectilis wch vis
projectilis is much greater yn vis centripeta
in perihelio & vis continually lessen'd till ye
plant gets half way & yn vis centripeta
is exactly eql to it. yn ye vis centripeta
increases & ye vis projectilis diminishes
~~till it comes to its~~ Aphelio, at wch time ye vis
Centripeta is much stronger yn ye vis
projectilis by wch means (ye plant is) again ~~ye . . .~~
drawn towds ye Sun & ye plants direction
making an acute Angle wth a Line drawn
to ye Sun & vis projectilis is continually
encreas'd. Just in ye middle between ye Aphe-
lio & ye Perihelio ye Centrifugal force are
eql to ye Centripetal: after yt ye vis projectilis
prevails, but yet ye Plant is continually
impelled towds ye Sun because of his acute angle

till it comes to its perihelion & there ye
vis projectilis is encreas'd again by
vertue of ye same ye Moon wch for ever turn
round ye Earth, ye Satellites of Jupiter
& Saturn round their respective
primaries ye primary planets in
Orbts a little Excentrical & ye Comets
in very Excentrick ones round ye Sun all
describing eqll Areas in eqll times; but
as ye Sun attracts ye plants & Comets, so
also they attract him & one another
thereby ~~Irregularities~~ irregularities in each others orbts
wch are more sensible in ye moons motio
because she is so nigh us; but Sir
Isaac Newton has demonstrated yt ye
one consideration of mutll attract.
well applied wd solve all ye Irregularities

hitherto observable in ye Celestial motio
of wch we shd give an instance in ye
following Objections. ———
112. A 3d Obj: agst Newt: Theory yt ye moon cannot be ex-
plained in her orb: by ye same Law whereby
ye other planets are retained in theirs, since ye
ye motio of ye Moon in many Cases, is observed to
differ fro ye other planetary motions: as
for inst: ye moon is obsvd to be accelerated
In her passage fro ye Quadratures tow. ye Syzigies
& vice versa, but say they had ye moon any
gravitatio towds ye Sun, it cd not but in its
whole descent towds ye Sun be Accelerated ie
fro Opposition to Conjunctio & retarded in its
whole ascent fro its Conjunctio round again
to its opositio for in ye former pt of its period
ye Actio of ye Sun Conspires wth its motio
but in ye latter acts Contrary. — —

113. to it. How[eve]r we grant ye mat. of fact to be true
yet it proves nothing agt ye Questio for
ye Moon seems to be twice accelerat'd & twice
retarded in one revolutio yet ye Action of
ye Earth does but once accelerate & once
retard it as ye primary planets suffr
but one acceleratio & one retardation from ye
Suns Actio; ye seemingly double acceleratio
& retardatio is owing ptly to ye Actio of ye
Sun, & ptly to ye Annual progression of ye
Earth; (as may be seen more at Large in
Whistons Prel. Phys. prop: 31. & Gravesandes
Astronomy, cap. 16.) so yt to a person hanging
in ye Air at such a dist. as nt to be at all
affd wth ye motio of ye Earth ye moon wd
seem to be accelerated in its whole descent
fro ye Conjunction to ye Opposition & re-
tarded in its whole ascent thro ye whole
parts of its orbit.

The Moon is acted upon by 2 Bodies
1st by ye Earth, whose attraction alone wd
cause her to describe eqll Areas
in eqll times. 2dly by ye Sun wch being
without ye Orbt must disturb ye motion
round ye Earth. ye attr. of ye Sun may be
Resolvd into 2 forces one of wch acts
from ye Moon to ye Earth & only alters
ye fig. of her Orbt & ye other acts fro
ye Moon towd ye Sun in a Line parallel to a
Line drawn from ye Sun to ye Earth wch as
it does not tend to ye Earth must alter ye
fig. of her Orbt & alt. ye proportionality
of her Areas. But as ye Earth is likewise
attracted by ye Sun nearly in ye same directn
with ye last force ye disturb. will be caused only by ye diff.

Of Moon's force: How it acts in Consequentia to ye Moon's motion it must accelerate it. & in antecedentia it must retard it. But it acts in Consequentia fro ye last Quadr to ye New Moon, in Antecedentia fro ye New to ye first Quadr & seems slow (The reason ye Contrary has been seen) to act in Consequentia fro ye first Quadr to ye full & in Antecedentia fro ye full to ye 3d Quadr. for in ye former case ye moon is Moving towd ye Sun & ye disturbing force acts fro ye Moon to ye Sun in a line parallel to a line joining ye Centers of ye Sun & Earth so yt ye force it must tend to increase her motion: in her ascend fro ye New to first Quadrature she is moving fro ye Sun & ye

Disturbing force still acts tow.d ye Sun
ye same manner Consequently her motion
must be in some measure disturb'd.
From ye first Quar.r to ye full ye force seems to
act on ye Earth to act in ye same direction
as before but fro ye Sun w.ch draws ye
Earth yt being nearer to ye Sun yn ye
Moon is & consequently attracted more
Strongly by it, so yt now ye Earth is pull'd
fro ye Moon, as before ye Moon was drawn
fro ye Earth, ye force being something less
fro ye Sun & her motion being likewise ye
same way she appears accelerated in her
Motion fro ye full she approaches nearer
ye Sun & ye disturbing force still seems
to act in ye same direction fro him.

Consequently the matter are apparently the art
and where is past. — — —

111 If the equat. lunar. of ye Moon's periodical
time & dist. fro' ye Earth is found to be greater
while ye Earth is in perihelio yn wn in Aphelio
wch Phænom. is obs. can by no means be accountd for
there, for see they by ye Sun's irregularity
can be explaind at all by ye theory of
gravity it must be explained either by ye
Moon's gravitation towds ye Earth or towds
ye Sun, but it cant be either ye former way
because gravity is allways as ye quantity
of matter, & it is plain yt ye Earth as well as
ye Moon has always ye same variable
Quantity of matter in perihelio & Aphelio

Neither can ye Inequality of ye Synod: Period be effected thro' gravity towards ye Sun, for ye Sun only decreases her motion from ye Quadratures to ye Syzygies & where it pro[motes] from ye Syzygies to ye Quadratures, [illegible] ye accelerations are greater in Winter, so are ye retardations greater; whereby ye ... of ye whole Period time ... ye Sun in perihelio as in Aphelio. —— —— —— ——

2dly. It may be answer'd yt when ye Earth & Moon is in perihelio, yt ye Sun being nearest ye Earth, diminishes ye gravity of ye Moon towards ye Earth & whereby ye dist. of ye Moon is encreased & her periodic Time lengthen'd. Further ye diminution of ye Moon's gravity towards ye Earth, must encrease her periodic time appears ... [illegible]

line of ye Moon, no gravity on ye Earth w^d
fly off in a tangent in infinitum & never
move round ye Earth, but ye Radius
w^d be infinite & consequently ye [illegible] means
her gravity to ye Earth [illegible]
tho: gravity [illegible]
periodic time is increas'd & [illegible]
decreas'd by yt w^ch ye Satellite is in perihelio ye Sun
has greatest force.

16: Whatever ~~[illegible]~~ was brought against Kepler's
besides these are [illegible]
[illegible] ~~[illegible]~~ planetary motions
arising from ye disturbing force of ye Sun;
[illegible] endeavour to explain
w^n we come to treat of Astronomy.

Opticks

1 Signifies Originally ye Science wch teaches
ye properties of direct vision but in a
larger sence it may comprehend ye whole
Doctrine of Light & Colours; 'tis therefore divided
into 3 parts first Opticks properly so calld
wch explaines ye severall properties of direct &
ordinary vision secondly Catoptricks wch
is a 2d division, wch Explaines ye propties of
Reflex vision & treats of ye Laws of reflection
3dly Dioptricks wch explaines ye Laws
& Nature of refracted Rays, passing
thro diff. mediums, as glass, water,
shape or essence & nature thereof
of ye Propagation of Light.

* That light is a body, proved from its being subject to y^e same general properties as Percussion, reflection, & impenetrability, the latter of wch is thus proved, Body can intercept nothing but body, Light is intercepted by body, therefore light is a body.

2 By Light we do not understand here, ye sensation wch arises in us upon ye view of any Luminous Object, but those small particles wch are continually emitted from ye Luminous bodies to our Eyes, thereby Exciting in us ye sensation of vision. By ye Rays of Light we understand as well those particles wch are Contemporary in one Line as those wch are Successive in ye same Lines.

3 I say necessarie, for since Motion & other inherent properties as illumination of opake bodies, its reflexion & refraction (of wch more anon) sufficiently prove Light to be a body; * it must certainly follow

of ye air it must be performed in time & not
instantaneously as ye Cartesians affirm.

4 Besides yt Light is propagated in time ap-
-pears fro plain matter of fact. I mean
Mr Roemer's Observations on Jupiter's
Satellites; ye times of whose Eclipses are
always found to be some minutes after
ye times they are calculated for, wch seem-
ing irregularity can be solved by no
other Hypothesis yn yt of ye Light's supposed
to require a certain time in passing fro
one (place) to another. ye Phaenomenon is ye
lessening of ye time of Jupiter's in his mean dist-
ance fro ye Earth, or rather ye Eclipse

Another reason y^t light is not instantaneous, for were light instantaneous, y^s absurdity would follow, y^t y^e same body might ~~seen~~ be seen in an infinite n^o of places at y^e same time.

of any of his satellites (suppose ye first) was
(observatio)
can per ye Calculatio to a Minute of time
wn ye Eclipse wd happen; either wn ye
planet is in his greatest or least distance
from ye Earth. but wn ye planet is in its greatest
Distance it wd not be seen till 7: 30''
after ye time it was calculated for, wn in
its least distance it wd anticipate ye time
of calculatio by 7 M: & 30 secnds. Now ye
diff. times of ye appearances of Eclipse
apparently depending on ye Diff. distance
of Jupit. from our Earth, ye sufficiently
proves ye Light spends some time in arri-
-ving unto our planet fro' thence. ——

N.B. Jupiter is in its greatest Distance fro
ye Earth wn he is in Conjunction wth ye Sun
yt is wn ye Sun is between us & Jupiter $\frac{n}{h}$
He may be sd to be in his Apogeū; & in his
Least distance or Perigeū wn we are between
him & ye Sun yt is ~~Sun~~ wn he is in opposition.
whence it follows yt ye Diffr of his distances
in Apogae & perigeo is = ye Diamr
of ye orbit of ye Earth. — — —

5 This Observation may be serviciable
in another respect. viz: in determining
ye Velo! of ~~Light~~; ye dis! between ye Earth
& Sun is divided into 10 Eqll spaces.
Jupiters Apogaeū is at ye distance of 6 Eq.ll
Spaces, his mean dist is computed at 5·2;

his perigæum alt? ... of ye Observations above mentioned ye Light takes up 7m=30s in moving thro 1/2 of these ye spaces wch is a radius of ye magnus orbis; & consequently 15m in moving thro ye Diamr of ye magnus orbis: again these ye spaces are computed by Gregory to comprehend 94696969 English Miles or 500000000000 feet allowing 5280 feet to a Mile. thus ye space Light moves in 7m=30s is after ye Rate of 210437 Miles & 3742 feet in a second wch is 1010101 times faster than ye motion of sound computing its mean Veloc. at 1100 feet in 1". —

6 It is hence ... of ye prodigious velocity of Light

may perhaps make ye following paradox in-
-credible viz: ye Light takes up above 6 weeks
in coming from ye fixed stars to us. (what
appears from ye observation of Hugenius
wch may be seen more at large in Philos.
Trans. No. [illegible]) & though their parallax
cannot be discover'd yet at least it can be is
such yt Light cannot run thro it in less
time yn we take up in making an East
India Voyage wch is usually perform'd in a little
time. having sufficiently convinc'd ye progress-
-ive motion of Light, by means [illegible] upon any
further particulars concerning its proper-
ties, as ye [illegible] of its [illegible] & [illegible]
experiment [illegible]

The Cartesians Hypothesis for ye Propagatio of Light Erroneous. . . . .

ye new Hypothesis of ye Light after ye nature of sound, Consists in a certain impression or motion of ye fluid Mediu interposed between us & ye Luminous Object. ye first pt of ye propo sition has been already examined, ye 2d ye like sound it consists in a certain dilatio of ye fluid mediu interposed, we thus confute. Light may be interrupted by opake bodys but sound (wch truly consists in ye dilatio of ye interposed medium) cannot. a gun let of behind a Mountain can be heard (wth a little) as plain as if no mountain were interposed, but if a mountain be interposed between us & ye sun,

All ye Rays coming immediately from the Body
to my Eye wd be intercepted & I shd see
nothing but Reflex light. The reason is
plain, because ye Light consists in par-
ticles emitted fro a luminous Body in
streight lines, but sounds are only ye Modi-
fications of ye fluid medium. & tis ye property
of a fluid in motion wn [illegible] is necessar-
ily interposed if any obstacle to surround ye
Obstacle & after yt to move on in ye same
directio, it wd have done, had not ye Obstacle
intervened: thus it is wth ye waves, Pulses, Vi-
brations of ye Air, & thus wd it be wth ye Rays
of Light too if, as they suppose, consist in
any modificatio of ye fluid medium...
Whence Hypothesis [illegible] of ye propagatio of Light.

the same time

8 Every Luminous point sends out an Infinite Number of those small particles of wch light is composed in all directions. wch is evident from hence, because ye same point may be seen by several hundred Men at once, as well as by one. whereas if every point in a Luminous body sent out but one Stream of Rays, none could see any point but he who should happen to come in ye way of yt Stream. —

9 The intensity of Light is always as ye density of ye Rays yt produce it & ye density at diff. dist. from ye lucid point is always inversly as ye Squares of those distances, as Keil has demonstrated concerning ye intensity of all Qualities whatever. Phys. Lect. 1. Thus let A A & H H be 2 pts of concentrical Circles, having ye

their Centre ye Luminous point &c ——

Fig: 4: sending out an Infinite No of Rays Cr.

Cr. R &c continually receding from each other as in ye Nature of Right Lines drawn from a point; Now ye Circumference of ye Rays wch fall upon ye Lesser Circle falls also upon ye greater — but ye Density of ye Rays being inversely as ye Space they take up & all Circles being (According to ye Rules of Geometry) as ye Squares of their respective radij it follows yt if ye Radius AA be to ye Radius of MM as 2 to 1, ye Density of ye Rays, wch fall upon each of ym being as ye Squares of their respective Radij reciprocally it follows yt AA wch have its Rays at but 1/4 ye Density of those of MM & Consequently ye light falling

upon all y^e sides of y^e as in being as falling upon it. y^e Light w^{ch} does not come to our Eyes immediately is seen by Means

Of y^e Reflexion of Light.

10 Every opake body except those w^{ch} are perfectly Black (if there be any such) reflects in some measure all incid^t Rays, & they in some measure; for there are no Bodies Capable of perfect reflectio, y^t is w^{ch} can reflect all incid^t Rays: White Bodies reflect y^e most & black ones y^e least

since we have no perfect white tis plain we can have no perfectly reflecting Body. those Rays w^{ch} after they have impinged upon any Body, are not reflected of again, are said to be [illegible] in y^t Body

11 A Ray of Light as receiving reflect[illegible]

(for if it fall perpendicularly it will reflect
perpendicular of the Circle) upon ye plane
[illegible] Whether plain as AB Concave as CF, or
Convex as EF, & being reflected to ye [illegible]
makes wth ye perpendicular wch is erected at ye
point of incidence C describes 2 ye angles
of [illegible] viz: [illegible] called ye angle of
incidence, ye other viz [illegible] called ye angle of
reflection. ye Equality of ye 2 angles of
incidence & reflection is proved by ye following
Experim.t take a looking glass covered all
over wth paper except one place, wch
must be left bare, ye placeing a candle
[illegible] uncovered [illegible] of ye glass [illegible]
since ye direction

of reflected Rays & ye perpendicular to ye incid-
ent ye Incident point wch ye is common to ye opposite
ye 2 Angles of incidence & reflection & beyond
ye lines of incid. & reflected Rays are always in one
& ye same plane perpendicular to ye Horizontal
plaine coincident wth ye Surface.

12: From an incid. Ray as H on ye B ye Dr. &c.
to draw its reflected Ray exactly or measure
one already drawn put one foot of ye Compasses
in ye point of incidence C & describe any ~~line~~ part
of a Circle as e a L &c. yn on ye side opposite
ye incid. Angle take ye lk = ye Ray lo as
lastly draw a Line from C to l & ye Line will be
ye reflected Ray C l exactly answering to ye
incid. one.

the measuring ye Angles of Incidence & re-
flection, wch being greatly [illegible] must occur
to treat of next viz: ye centers of parall[illegible].
[illegible] we can conveniently come to explain
ye [illegible] Phænomena of mirrors [illegible] will be ne-
-cessary to explain something relating to
vision in general, of wch we shall have occasion
to speak more at large hereafter . . . .
13 pl. To know how ye Eye perceives ye true dist.
of any Obj. point we must observe yt if a
point in a Luminous Body send out but
one pencil of Rays, we can never easily
determine ye dist. of ye object [illegible] we c. indeed
know yt it is in ye line described by ye beam
of light, but not yet at wt. pt. of it. ——

But since every point sends an infinite No of Rays in all directions; we may take ye Lines yt any 2 streams of Rays (out of all those yt come to ye Eye) describing & referring ym back to ye obj. point wch ye point of Intersectio of ye 2 Rays thus drawn back must fall perpendicularly, one upon each Eye & consequently pass thro' ye Centre of each Eye whence they are Called ye axeis optici. — — — —

2dly. According to ye Angle wch those lines (wch is called ye optick Angle) inclines more or less to a Parallelism, we judge ye Obj. to be more or less Dist. —

3dly we Estimate ye Magnitude of any Obj. by ye Magnitude of ye optick Angle

4thly we judge an Obj. to be misplaced wn ye Rays coming fro it to ye Eyes being produced back again, do not meet in ye former point.

13th. The only effect of the Rays accompanied wth these
conclusion of light to have been [illegible] since
we look at it last [illegible]

14th. The reason why a mirrour represents us
an Image either of any other Body, is every
body smooth [illegible] of the Rays wch reflected
are carried to the Eye in the same order they came
for the Cons: of the several kinds of mirrours we'll
touch only upon 3 sorts: the plain, Concave &
Convex. as for others their Phaenomena will be
very Easie to be solved by the principles on wch
those Speculas depend [illegible]
therefore first let us treat of the plain
Speculum..

15th. Images seen in the plain Speculum are
always Erect.

As large as ye Obj. appear behind ye Glass as it
is before it, all wch is made plain & Exempl.
Fig. 9. beholding ye Mirrour AB ye Image of ye
Obj. D. [illegible] it is plain yt ye point D. wch appears at i
for ye Rays DE & DG. wch reach ~~[illegible]~~ ye Mirrour are reflected
DE to C & DG to H. are ye Rays EC & GH
Reasons of wch ye point D. acts on ye Sensorie
of sight, wch enter ye Eye as if they came from L
& ye reason is plain because point L as is shewn at
13) ye Eye always defines ye true distance ~~of~~ of any Obj.
at ye point of Concourse of any 2 Rays drawn
Down from ye obj. to ye Eye, wch point of Concourse
is at L: for ye reason also must ye point E be
seen at M. hence it is plain yt ye Image must
be as big as ye Obj. & appear behind ye Glass as it
is before it;

For ye triangle AA is eqll & simil to ye triangle
FAD, ye Image must also appear erect,
because ye Rays wch express ye upper parts of ye
Obj: are carried without crossing each other
to ye Upper pts of ye Eye, & those wch express ye
Lower pts are carried to ye Lower pts of ye Eye;
thus DG & DH are carried to C D & E to H
What has been sd of ye points D & E may be apply'd
to all ye points of ye Obj: in like manner

Of ye Convex Speculum.

In ye Image of ye Obj: seen in ye Convex Glass
Fig 10. at C seems to ye Eye at DH, (let ye Object
be at a little distance behind ye Glass,) ye Object is
erect. for ye Rays EB, EG, DM, DH,
fall upon ye Glass in such a manner as they

Reflex Rays [redacted] , are (by reason of their diverging more yn usuall fro one another) carried to ye Eye just as if they came fro L, ye reason of wch their diverging is owing to ye equality of ye Angles of incidence & reflectio as wch is now easily proved, so Rays incidt on a convex Glass yt draw their reflected ones producing ym till they meet in points as behind ye Glass as in fig 4. vid. sect. 13. 2. & 3. par.

Of ye Concave Speculu. —

17 as ye concave Speculu is quite ye reverse of ye Convex so are its Phænomena quite Contrary they vary also according to ye Diff. positions of ye Eye & ye Objt. ~~as if ye Eye at D~~ beholding ye Concave Glass A E, ye Centre of wch (wch is placed between ye glass & ye Centre of ye Glasses concavity)

ye Image wd be seen at H M erect & larger yn
ye Obj: & further behind ye Glass yn ye Obj: itself.
& it because ye Rays of ye Pencils EB
GKD, & HLKD are sent to ye Eye without
Crossing. more remote, because EB, EG,
EI, FL are carried to ye Eye almost parallel
therefore ye Imaginary points of Concourse
H & M wd be at the greatr distance behind ye glass;
ye Objt appearing larger in ye case naturally
follows from those Causes wch make it appear
more remote. Vid; Sect. 13. 13. ——

15 2dly, If ye Obj: be placed in ye Centre this
being ye sd incid: & reflected Rays viz:
ye Radio must coincide wth one another

According to ye 11th because they fall perpendicular; ye 13th. For ye same reason if ye Eye should be placed in ye Centre it should see nothing but its own Image diffused all over ye glass. ———

F/20 14th. If ye Eye be removed beyond ye Centre a little towards ye glass & ye Eye should draw something further off as to K ye Image would be seen between ye glass & ye Centre viz: at HM diminished & inverted. For ye Rays EH, EM, &c. [illegible] are so reflected as to cross each other at ye points H & M & from thence to ye Centre diverging [illegible]. Then because ye other reflexion meets at H & M ye Image (according to Def. 13) [illegible]

will be seen at H M, & K, & L, by
intersect yourselves. y^e Images w^{ch} be con
verted (Art. 16) will also be diminish'd
because y^e pencils preceding are &c
after refraction converged gradually.

20. If y^e Eye be placed at H M y^e Images
indeed appear behind y^e glass, but at
an indeff. dist.: & y^e reason is plain
because y^e axes of their pencils cannot meet
(w^{ch} y^e places of Obj^s can be assign'd)
since y^e Rays H L, M G, being pro
duced beyond y^e Glass w^d continually
diverge. Therefore it is certain y^t if y^e
Eye

we have nothing but our prejudice to help us to determine ye dist. of ye Image for knowing before hand ye dist. of ye Obj. fro ye Eye we thence estimate & determinate ye dis. of ye Image be[illegible] it ye Refraction of Light.

22. [illegible] ye Nature of Light to be propogated in right Lines so long as ye medium thro wch it passes continues ye same: but wn it passes out of one medium into another differing in Density it varies ye right Line it wd have passed in had not ye latter medium turned it aside; a Ray of Light thus varying its course is sd to be Refracted.

29 In ye same medium ye lines of incidence & refraction are proportionable in all obliquities, let AB be ye
Fig 13. surface of water. IL ye incid. Ray wch tends direct to C but by ye Attraction of ye water is drawn out of its Course so falls upon D. now in order to find ye lines of incidence & refraction erect from ye point of incidence L ye perpendicular EF, & from ye points I & D draw 2 Lines IK, QD, parallel to AB; then are called ye Lines of Incidence as IK & refract as QD; wch 2 Lines are in given ratio in all obliquitys of ye incid. Ray, so yt if ye proportion be known in one incidence tis known in all if ye refraction is made out of Air into water ~~[illegible] ye line of incidence is as 3 to 4~~ ye Line of refraction of ye Ray, Light is to its line of incidence as 3 to 4 if out of Air into glass

y^e lines was as it lost in sight of other colours
y^e lines have other proportions but y^e
Diff^ce is so little y^t it needs little to be consid^d
refractio is y^e strong in passing out
of a denser mediũ into a rarer as out of
a rarer into a denser but contrarily made,
for if y^e contracted ray come out of a denser
mediũ fall on a rarer it w^d be refracted
a perpendicule to w^ch was it w^d come out
of a rarer into a denser mediũ is refracted
a perpendiculũ. viz. to y^e same former Case.
Velocity of y^e Rays is increased y^e refractio
in y^e latter th diminished y^e Ray approaching
nearer a perpendicular .. y^e Cause of refractio
assign'd ..

24 The Cartesians Imagine yt a Ray passing thro a Denser medium into a rarer is refracted frm ye perpendicular because it meets wth a greater opposition frm ye denser medium & vice versa. but ye Hypothesis is far from accounting for all ye Phenomena of refraction whereas they are all easily solvable by ye Newtonian Hypothesis wch is founded upon all ye mutuall Attraction of Light & Bodies wch therefore must be admitted as ye true cause of refraction yt there is such a mutuall attraction between Light & Bodies exerting itself at a Certain dist. (supposed to be abt ye 15th or 16th pt of an Inch) appears from ye following Experim.

Let a stream of light into a dark room & expose
at ye abovementioned dist. fro ye Rays [illegible]
ye Edge of a Knife & ye Rays wch pass by it
come to ye Room but dont be affected
but by ye mutuall attraction of ye Rays of
Light & Edge of ye Knife: whilst we do
cannot see ye Rays of Light till they be reflec-
ted fro ye wall they are brought to our Eyes,
we are, & yt tis impossible for a room to be
so void of dust but yt there wd enough be
left to reflect ye Rays to our Eyes before
they come to ye Wall; & ye motion of which
may easily trace ye stream of Light
& thereby discern ye bending of it: w. I hope
next proceed to. — — —

The first Phenomenon solved
by ye foregoing Principle...

25 A perpendicul^r Ray suffers no refraction, for since ye attractive power of ye dense medium inclines perpendicul^r to ye refracting plane as is exprest in ye 13 Fig. & ye Rays cause: it wd follow yt a perpendicul^r Ray should be turned out of its Course, but only be accelerated in its ~~course~~ passage thro because of ye att. of ye denser medium; in ye receipt lets in ye directio of ye Ray.

26 A Ray passing out of a rarer Medium into a denser is refracted ad perpendiculum; ye Motion of ye Ray AL is Compounded of 2 other motions a perpendicul^r & an Horizontal one wch consequently make it describe a diagonall.

wn the Ray comes within the Sphere of Attraction of the denser medium its perpendicular Momentum is increased; on wch acct the Ray instead of keeping on its Course to C is refracted to D which is ad perpendiculum. ——

27. 3dly. on the contrary when the Ray D E comes incident passing out of a denser medium into a rarer the same attract. force casts it upon F, wch is a perpendiculo. the denser medium attracting the Rays in the same manner whether it goes out of a denser into a rarer or out of a rarer into a denser medium.

28. 4thly. The refraction a perpendiculo is stronger as the medium into wch the Light passes is rarer.

For wch a Ray passes thro glass into air
it is attd both by ye glass & air, but glass being
much denser yn air it wd attr ye ~~air~~ Ray wth
greatr force backwd. Likewise wn a Ray
passes thro glass into water it is more strongly
attrd by ye glass yn by ye wr & consequently
is pulld back again; But ye Diffce of ye
densities of glass & wr being much less
yn ye diffce of ye density of glass & air ye
Refractio wd be much more strong in ye
latter case yn in ye former according as
ye Excess in one is greatr yn ye Excess in
another for ye same reason ye refraction
is strongest of all wn a Ray pass into a
Vaccum.

and the Momentum with which it passes is diminished, it being inversely as the Sine of incidence; & if so much &c

29. Obs. A Ray coming thro' denser into rarer medium wd not immerge under certain ob-liq., but be drawn back into ye same medium, thus if ye Angle of its obliquity fro wa. into air be wth ye 40d 41 or fro glass into air wth ye 44 it wd not be transmitted but be pulld back again. Because ye more obliq ye it moves ye Longer it is in getting out of ye attractive Sphere of wa. wch exerts itself at a sensible dist. both above & below ye refracting surface & if so much of ye refracting surface acts upon ye Ray as sd be able either to stop or overcome

the momentum wth wch its impell'd it cannot possibly Emerge. — — — — —

30th 6th. Refraction is made at or near ye point of incidence of ye Ray I L falling obliq. upon ye surface wch divides ye medium. or rather on ye surface where ye Attrac. begins, yt draws ye Light tow. ye Wat.; wch it comes to ye Upper Line aaa its turn'd out of its right Line by ye force wch attract it to ye Wat. & indeed it is bent out of its right line in every point as long as it lies between ye upp. & lower Line aaa between wch ye Attrac. acts & therefore between those Lines it describes a Curve such as projects moving;

beyond ye lower line, ye selectis benes [illegible]
ye Ray ceases, therefore from ~~the~~ thence it moves
in a right Line. ye reason why ye refracted
Ray no longr describes a Curve is because
after it has passed ye lower line, ye pt of
ye mediu being above ye pt below & on
allsides of it, it wll be attracted on all
sides eqlly, wch attractio being equivalent
to none at all, ye Ray aftr ye wch not be
hindr'd (13) fro going on in a rectilinear wd.
& as wll be no more refracted. ye is a
Phænomena no way to be accd for by ye
Cartesian Hypothesis; for if (according
to ym) ye Refraction of Light was owing
to ye resistance, ye Ray must wth fro ye pts of
ye Medium;

since they continually suff.r ye same resist-
-ance as they pass thro they ought be conti-
-nually turnd out of their course
thereby describing crooked & curve lines
But ye dist.t between ye lower & upper
Limits is so small (& consequently ye
Curve made wth ye Mo so imperceptible) yt
refractio may very well be sd to be made at ye
point of incidence.

31. The refractions of mediums are gen.ly
proportionable to their densities wch
is easily solvd by Attraction, for ye dens.e
a Body is ye great.r Numb.r of Attractive
particles it doth contain in any given
Space;

therefore a Ray falling upon one medium or
yn another wd be attr. by a greater No. of parti-
-cles & consequently wd be more refracted.
but ye Rule is nt wthout Exception; for
Sulphureous bodies will attrt Light more forci-
-bly yn some other Bodies of greater density
wch is ye reason why they take fire so soon-
32. -ly the reason why ye Sines of Incid & refracn
are always in a const ratio. is owing to ye
Constancy of ye Cause wch produces ye Re-
fraction viz. Attrn for since in all mediums
of one & ye same density ye attracn is invariable
it wd follow yt ye Refractn wd be at all dists from
ye first pt of Incidce and all velocities of ye
Incidt Ray be at a const & invariable ratio
we shd conclude wt we have to say on ye Head with;

Some Phænomena of Nature accd for from ye Refraction of Light.

33 Put a piece of Silver into a Bason & stand at such a distance from it yt you may just lose sight of it yn pour water into ye Bason & ye piece of Silver wd appear, wch we thus accd for. before ye water was pour'd into ye Bason some of ye Rays wch were reflected from ye Silver flew over our Head, but upon pouring in ye watr these Rays being Refracted a perpendiculo are carried

34 directly to our Eyes. So if a piece of Stick be put ptly in partly out of ye water it appears crooked, because ye Rays coming from yt pt of ye Stick wch is undr ye water;

are affected by ye dense medium, & therefore ye Obj. doth not appear in its true place.

Of Opacity & Diaphanity.

35 It was ye opinion of ancient Philosophers yt all Pellucid Bodies transmitted ye Rays of Light in strait manners, so disposed, yt they meet wth no opposition in their passage, & yt ye opacity of some Bodies arises from ye many Impediments Light meets wth in its transmission, but more modern Improvers have shewn ye Hypothesis, to be altogether insufficient for explaining ye Nature of ye Opake & Pellucid Bodies & have shewn also yt Diaphanity is not owing to any

particul^r disposition of y^e p^ts of matter but
to its great rareness. see Nolled. Lariss; opt. yull. 2.
sect. 13, 14, &c p. 283.
30 Accordingly S^r Isaac Newton in his Opticks
shews y^t Bodies are much more rare & porous y^n is
commonly imagin'd, Water is 19 times lighter &
consequently rarer y^n Gold, & yet Gold is so
rare as to transmit y^e Magnetick Effluvia
without any diminution of y^m & easily to ad-
mit Quicksilver into its pores. & so it is at
least three times as appears from y^e Florentine
Experim^t cited by M^r Locke (l. 2. c. 4. §4)
w^{ch} we may conclude y^t Gold has more
pores y^n solid p^ts & perhaps more y^n
1000 times as many. Yet we can't conceive
those particles to be so disposed y^t they may be

as much porosity or space interposed between 'em as their own Bulk; in ye same manner let us suppose those particles to be made up of others between wch there is interposed a like Vacuity & so on till you come to ye particles wthout any pores. yn if in any Body there be for instance 3 of these sizes of particles it wd have 7 times as much Vacuity as solid Matter (provided ye least be ye most solid or least sort) & if you suppose it to have 4 such sizes of particles it wd have 15 times as much pores as Solidity if it have 6 it wd have 63 times more pores yn Solidity & so on whence tis possible there may be vast greater pores & Vacuities interposed in Bodies. ——

so yt if there wd. no other cause of Dia-
phaneity y.n only transversarious pores,
in ye world so contriv'd as not to impede
ye passage of Light; 'tis plain yt all
Bodies wd be more or less transparent,
since all of ym wd have free & open spaces
sufficient for ye passage of Light,
but we find yt ye rarest Bodies such as
Cork are not always ye most Diaphanous
therefore it is plain yt Diaphaneity
must be attributed to some other cause
beside ye abovementioned; wch we
come next to prove more fully, viz:
that Transversarious Pores alone

are not sufficient to rend.r a Body Dia-
-phanous.

34. If a Cube of Glass be held tow.ds ye Sun
it w.d be very transparent, let any side be
turned tow.ds the Light; but were it ye
Eff.t of any disposition of ye p.ts and
order; for the meatus's on one side must
necessarily be an hindrance to those of ye
other.

35. 2dly It's hard to imagine how ye p.ts of stone
& sand sh.d only by being melted into glass
have all their irregular meatus's
put into ord.r & their p.ts acquire new
positions w.ch they had not before

But ye true cause of their growing pellu-
-cid wn melted (wch cannot well be [illegible]
by ye Cartesian Hypothesis) shall
be shewn hereafter. —— —— ——

39 If ye Diaphaneity of a body were owing to
any disposition of pts it ought to be vio-
-lently disturbd to lose ye peculiar struc-
-ture of pts & become Opake, but we find
that ye most violent motion does not in ye
least diminish its Diaphaneity, yt
naturally brings us to think of ye true
reason of Opacity & Diaphaneity.

40 From wt has been sd above it appears
sufficiently, yt to have been various
Dores (the 1st & ye Chief)

ytity is not ye only condition requisite to render a Body Diaphanous. For 1st A Body yt is pellucid must be all over of an uniform density otherwise a ray passing thro it wd be continually attracted ~~lo~~ fro as it met wth rarer or denser pts. in ye Body; till at last it wd be entirely suffocated. 2dly ye Pores of a Diaphanous Body must also be very small wch follows from ye Necessity of their being uniform. for large Pores by admitting of particles of air wd render ye Body Heterogeneous and Consequently Opake. besides Light passing thro a large pore;—

And bring nearer one side of ye Pore if
ye mother wd. be attracted towd. ye nearest
side & wd continually be so attracted as
often as it wd not in ye Center of ye Pore
whereby it wd suffr innumerable Re-
fractions, & consequently must
needs in yt case also be suffocated.
whereas in small Pores ye sides being
at no ~~[illegible]~~ sensible dist. from each
other ye attractive forces of ye sides
must Naturally destroy eachother
leaving thereby a free & undisturbd
passage for ye Rays of Light.

41. What has been prov'd from reason is also
confirm'd by experimt. for the we cannot

make experim^ts^ whereby to fill y^e^ Pores of a Body w^th^ a medium exactly or y^e^ same density w^th^ y^e^ Body; yet we find y^t^ opake Bodies become transparent by having their Pores filled w^th^ any substance of almost eq^ll^ density w^th^ their p^ts^. thus Paper dipt in wat^r^ or oyl, y^e^ oculus mundi stone steept in wat^r^ & many other substances soakd in such Liq^rs^ w^ch^ intimately pervade their little Pores, become more transparent by y^t^ means then otherwise. So on y^e^ contrary y^e^ most transparent sub^s^ by evacuating their Pores or seperating their p^ts^ may be made sufficiently opake

As wel Paper or occulus mundi stone, soap in wa^t by being dry'd, Horn by being scrap'd, y^e Glass by being powder'd or otherwise flaw'd: Turpentine by being mixd w^th wa^t & stird ab^t till they mix imperfectly.

42 The reason why stones & sand, y^e Mate-rialls of glass, w^ch melted become diaphanous, is plain, ffor w^n they are reduced to fluids their p^ts pressing fro all sides togeth^r they w^d not suffer any inequalities in their texture nor harbour any Heterogeneous matter but throw it off in dross.

43 To conclude, opacity seems to arise

from ye many reflections, Refractions & inflections wch light meets wth in passing thro Bodies consisting of such very many plt. & large Pores; whence Diaphanity arises from ye Bodies having their Part. all Homogeneous & Pores so small (& consequently their Abstract so equable) as not to cause any Refractions, Reflections, or Inflections.

Of Lenses:

44. A Lens is a pellucid Sphericall Glass, of wch there are 5 sorts. 1st plane on one side & convex on ye other. 2d Convex on both sides. 3dly plane on one side & concave on ye other 4thly concave on both sides.

are physically parallel

6thly Concave on one side & Convex on ye other,
wch may be referred to ye concave or convex
Lenses as ye one side or the other is
predominant. we shall here take notice
only of ye properties of 2 viz. those
of ye 2d & 4th sorts of ye Concave & con
vex Lenses properly so called: ---
48 1st A Convex Lens (3d sort) collects parallel
Rays passing thro' it into a focus upon
Burn: wch ye principle of burning glasses are
founded; because they collect ye Rays of ye
Sun (wch upon ye acct of ye immense dist.
of yt Body are esteemed as parallel)
into a small space & by reason of ye
fire wch was before dispersd is now
collected.

& ye reason of ye motion of ye fire accor-
-ding to various directions these Rays
are collected burn violently. ——

46. Diverging Rays either diverge less
or run parallel or lastly converge,
& converging rays converge more
wn they converge out of the Lens.

47 When a Ray passes thro the centre of a
Lens, its direction is not changd, for
yn 'tis ye same case, as wn light passes thro
a medium terminated by 2 plain Surfaces
as is evident from ye Tangents being
drawn on ye points of incidence & emer-
-gence of all those Rays, wch passes thro ye
centre of ye Lens & reason why ye direction
of a Ray passing thro a medium,

terminated by 2 plane Surfaces suffers no Change, is because as much as it is turned to one side at its entrance so much exactly it is turned ye other way as it goes out of ye same medium according to Sect 24. ye same holds good wth respect to ye Concave Lenses

48 all wch propertys of ye glass may be reduced to ye

Fig 19th examining ye double refraction at ye entrance & emersion of light. Let C be a radiant point sending out ye Rays A.B.I, AE, AK; since it passes thro ye Centre it is carried directly to AB, it is refracted as perpendicular to be thence carried to refract as perpendicular (coming out of a Denser medium into a rarer)

to a pt. A D is refracted to D: hence to a:
ye same happens to ye Rays converging to h
& H, wch is also called Converse to h, As
called ye focus, of ye diverging Rays, &
of ye converging.

49. Parallel rays are collected into a focus,
Diverging Rays continue Divergent or run
parallel, or lastly converge. From ye
foregoing cases relating to Rays transmitted
thro convex Glasses, we shall explain here
more particularly, having first premised
ye following propositions.

1st ye Poles of a Glass are ye 2 Extremities of ye
Radij of ye Convexities marked ——
2dly ye ... E. ye principle focus is ye point into
wch parallel Rays are refracted,

or from w^{ch} Rays diverging are refracted parallel

3^{dly}. Let LL be a Lens of unify^d convexities, A, L, B, E, being y^e Radii of Curv.^r C of y^e Lens is a point in y^e Radius taken somewhere between y^e 2 Poles but nearest to y^e pole of y^e Convex Surface in such a manner LC: CE :: AL: BE. If 2 parallel tangent Lines be drawn y^e same may be determined expeditiously, by drawing a line to join y^e points in w^{ch} they touch y^e convexities, for y^e ~~Centre~~ Line cuts y^e Line in y^e Centre. ~~[illegible]~~ wherein y^e Focus is. For y^e [illegible] of knowing y^e Centre see y^e 44 Sect. we come now to explain all y^e Cases of Convex Lenses.

50^{th} Case. If parallel Rays are collected in to a focus, y^e Dist. of w^{ch} from y^e nearest pole of y^e Glass is thus determined. Let BD be a convex Lens having for its Radii y^e lines A.B: ED:

incr^d, ye find ye focal Dis^t. AB, ye parallel
Rays pt, ye Ray as ye Sum of AB & CD is to
Fig: 16 twice AB so is CD ye other Radius to AB ye
focal Dis^t. required. yt is as ye Sum of ye Radij
of both convexities is to either radius dou-
-bled so is ye other Radius to ye focall Dis^t.
if ye same be sett in numbers (AB being
to CD as 25 to 82) ye work will stand thus 107
(yt is AB + CD) is to 50 (yt is twice AB)
as 82 (or CD) is to 34 (or AB). if ye focus
be taken on ye other side of ye Glass as at
d ye 1st Dd be equall to AB, [illegible] wth AB &
CD; CD twice as AB: Dd [illegible] is in numbers
107 : 164 :: 25 : 34 wch is ye former focal Dis^t.
If ye 2 radij are equall ye focall Dis^t. shall
be ye Radius of Convexity. for ye sum will
be as ye Diam^r. : to ye Diam^r.: ye Radius to
ye Radius.

51. Case 2. All Rays diverging from ye point F,
go thro ye 2d Focus parallel, for if ye parall
el Rays are refracted to F, 'tis certain yt Rays
diverging from F will be refract. Parallel.

52. Case 3. All Rays diverging from a point taken
Fig. 17. somewhere beyond F wil be more yn refracted
parallel, yt is they wil be brought to a Focus on
ye other side of ye glass in such a manner yt ye
More ye Radiant point is fro F ye nearer wil
ye Focus be draw to ye glass: for ye more dist.
ye radiant Point is ye less do ye Rays wch
from it diverge & ye less they diverge ye more
easily is yt divergence corrected & ye sooner
they are brought to a Focus. therefore &
Contra as ye radiant point approaches F
ye Focus must recede from ye glass ye dist.
D F is thus determined R F : F B :: R B : D F

or suppose ye same be done by Numbers R: h:
being taken 25 & R: h: 24 it will be as 25 : 24 :: 12 :

23 Case ye 4th. If ye radiant point be placed between
Fig 10 ye F & ye glass ye Rays will Diverge so much yt ye
glass can neither bring ym to a focus nor a par
-allelism but will only make ym diverge less,
therefore ye Rays will proceed as if from an Ima
-ginary focus D some where beyond ye F & as ye
radiant point approaches ye glass ye Dist.
of ye Imaginary focus increases ye higher Rays
brought to F: for in ye former Case ye
Divergency of ye Rays is increased, & in ye latter
diminished and its certainly more any
Lines diverge ye nearer is ye point from wch
they diverge & vice versa ye Dist. is thus
determined, say as R: h: P :: R: P: f: f:
in Numbers thus R: being 5 & R: P: as 5 : 15

8 : 20 $\frac{1}{5}$. N.B. In which cases y^e thickness
of y^e Lense B. w^ch w^d otherwise cause
some small Variatio from y^e foregoing Rules
is rejected as inconsiderable.

14 As for y^e Concave Lense its more or less being quite
contrary to those of y^e Convex, they may
be easily deduced from w^t has been s^d already
Parallel Rays passing thro a Concave
Lens become diverging, diverging
Rays diverge y^e more. Converging
Rays converge y^e less or become par
-allel or go out of y^e Lens diverging.
thus let QQQQ be a Concave Lens trans
-mitting thro it y^e Rays AB. Ab, Ad,
coming from y^e radiant point. A,

y^e Ray IL passing thro y^e Centre & goes
Strait on fro thence to C according to p^r
46 Sect: y^e Ray AB instead of passing
to Q is carried ex refractio ad perpendicul
to O, thence a perpendiculo to I. As
Rays are inflected tow^ds y^e Axis of Con
-vex Glasses so on y^e Contrary they are
deflected fro^m y^e Axis of Concave ones
whence it is certain y^t parallel or diverg
-ing Rays transmitted thro a Concave
w^{ch} proceed as fro^m a point betwixt y^e true
Radiant point & y^e Glass, for since y^e
Divergence of those Rays is increased
y^e point fro^m w^{ch} they diverge must be

brought proportionably nearer ye glass ye point of divergence is comonly called ye focus; ye Rules for finding ye foci of concaves are ye same wth those for Convexe provided ye Radiant points of ye concave Considered as ye foci of ye other & be like taken on ye same side of ye glass thus if ye foregoing scheme instead of a Convex of eql radii if ye be a radiant point ye Rays proceeding from it will be reflected by ye glass & ye Lens in such a manner as if they proceeded from ye point A; again if yt happen ye Lens [illegible] a Concave ye parallel Rays pa. shall go out of it as proceeding from ye point,

of ye Rays coming ~~###~~ fr. F. will be refracted
parallel. Having explained ye properties
of Lenses, wch is an Instrumt. of prime use
in ye Camera obscura we come now to ye
Solution of ye Phænomena.

The Phænomena of ye Camera obs-
-cura explaind.

591. These things are necessary to ye formation
of ye picture, Shape, Shade & Colour all
wch an exactly express'd by ye Camera, obscura
1st. as to ye Shape, suppose ye 3 radiant
points A B C emitting Rays, wch ye Lens
Fig. 4. (B D b plac'd upon a small hole in a win-
Dow-shutter) into a Room quite dark
all those Rays wd be collected into points

Corresponding to each viz: y^t a h expressed
upon a piece of paper held just upon y^e
focus of y^e converging Rays, those points
w^ch are near y^e same proportion to one another
as y^e same points are in y^e Extern Obj:^s
& y^e Chief points lay in a triangul^r
Form so w^ch y^e points of y^e Image: if in
parall^ll w^th y^e pictures be formed on y^e (paper)
126 A. long Shade, suppose y^e point h sends
all more Rays y^n A. y^n h w^ll be more
enlightned y^n a & y^e same sorts of
Rays w^ch proceed fro A. w^ll fall on a
whence y^e Colour as well as y^e Shape
& Shade of y^e Exter^l Obj^t w^ll be exactly
painted on y^e Image cast on y^e Paper

If any of ye External points change place their representations will also change place on ye Paper whereby motion will be also expressed. ——

524 The Image appears inverted, for ye Rays tho they do not Change their situation wth respt to each other yet wth regard to ye paper they do, for ye Rays wch come from ye right side of ye Obj. are cast upon ye left side of ye paper & vice versa: so of the right & left: ye same is true Resp. of ye upper & lower Rays.

525 That ye Obj. are seen most distinct in ye focus for wn ye Rays are gone past ye converging focus; it is plain yt those wch deviate from any particular point in ye Obj.

must now describe a Circle w^{ch} Circle increases as they recede from y^e focus. Now if we suppose 2 or more points in an Obj^t close to one another y^e Rays w^{ch} proceed from these points w^{n} they are gone beyond y^e focus swelling into Circles, some p^{ts} of y^e Circles must Coincide w^{th} one another, whence arises y^e Confusion in y^e Obj^t. —

17. Pict^{es} may also be formed by admissio of Light only thro a small hole w^{th}out y^e help of a Lens; for Rays coming fro ... Obj^t w^{ch} ... have y^e same proportion w^{th}out as w^{n} transmitted thro a Lens. But whereas in y^e former case they are Collected into a point at y^e Converging focus they w^{ch} now cast

upon ye Paper in Circles, wch as we have shewn
before causes confusion in ye Obj: of ye
Representation of Images in ye Camera
Obscura. has great affinity wth ye expermt
ye Objects, wch we see are represented in ye
Eye, as will appear for ye Structure of ye Eye.

66: The figure of ye Eye wn taken out of ye
Head is nearly Spherical, only ye fore part
is something more convex yn ye first,
ye part CD wch is most convex is transparent
& like ye segment of a lesser Sphere, tis therefore
Called ye Tunica Cornea. ye other covering
of ye Eye EABE (except ye Cornea)
is Called ye Sclerotica from its hardness
ye part of ye Sclerotica yt is next ye Cornea
is a coat called Uvea;

having in ye middle a hole we call ye Pupil;
The Uvea is made up of concentrick circular
Fibres intersected at right angles by other strait
fibres: if ye Circular Fibres are swelld ~~& strait~~
ye Strait ones are relaxed whereby ye Pupile
is lessen'd or contracted & a Contrary
motion of ye Fibres increases or widens it.
7. In ye middle of ye Eye, but nearer ye fore pt.
there is a transparent soft Body like
a convex Lens, whose hind pt. is more con-
vex yn ye fore pt. this is call'd ye Chryst-
alline humour; its axis coincides wth ye
Axis of ye Eye, wch goes thro ye Centre of ye
Pupil & of ye whole Eye. this Chrystallin

Humour is sustain'd by ye small fibres fix'd to all ye points of its Circumference & likewise to ye inside of ye Eye. they are inflected in ye Form of an Arch & every one of them is a Muscle, they are called Ligamenta Ciliaria of which only 2 Cc & Cc can be represented in our diagram; they are close to one another & together with ye Chrystalline humour make a separation in ye Eye dividing it into 2 Cavities one forward ye other Backward SS. ye formost Cavity is fill'd with a Liquor like water call'd ye Aqueous Humour ye inner Cavity is fill'd with a transparent Humour

Nearly of ye same consistency wth ye Aqueous
but not so fluid. ye 3d called ye Vitreous Humr:
2 The hind Surfaces of ye Eye is lined wth a coat
called ye Choroides, wch is again covered
wth a thin membrane called ye retina. At
ye Back pt of ye Eye a little on one side is
ye optick nerve wch is joined to ye Eye, this
is as it were an expansion of ye optick —
nerve, for ye expanded Coat of ye Nerve form
ye Choroides & ye Sclerotica of ye Eye, wch
make up ye retina Concurring, make ye
Marrow of ye Nerve; wch passes over ye
other pts of ye Eye; wch are of no immediate
Use in Vision.

53: The Coats here mentioned are 6 ye Cornea
Adnata, sclerotica, Choroides, & retina
which may be reduced to these 3 principal
ones. 1st ye sclerotica comprehending
ye Cornea & adnata. 2dly the Uvea; 3dly
ye Choroides comprehending also ye
retina. ye Humours are 3. ye Chrystalline
Aqueous, & Vitreous; we may Imagine ye
Chrystalline placed near ye Pupil to
be ye Glasses placed near ye Hole in a window
Shutter; ye Pupil answering to ye Hole;
ye retina may be compared to a paper
on which ye Images are cast. having ex-
plained ye make & texture of ye Eye we
come next to explain Vision in ye
Camera Obscura. — —

64: Rays flowing from any point as R. A. [illegible] enter
ye Eye thro ye Pupil & coming out of a
rarer into a denser medium, thro a spherical
surface, wch (if ye point be at a due distance
fr ye Eye) after refraction converge: where-
fore only superiority of ye Cornea & aqueous
humour there, there wd be in ye Eye an
inverted picture of ye obj, [illegible] con-
fused like ye pict in ye Camera obscura
formd only by admission of Light into a
Room wthout ye help of a Lens. The Con-
verging Focus wd be also beyond ye Eye
but by means of ye humours & especially
ye Crystalline, ye Rays are refracted

of ye Rays come together just in ye retina, at ye
point or place where ye Image is distinctly
represented. — — — —

6 As in ye Camera obscura ye paper wch
receives ye Image must be placed justly
in ye focus of ye Converging Rays yt ye
radious pencils may determine their union
exactly upon it, so in ye case of plain
Vision except ye Pencils determine ex-
actly upon ye retina at ye points all
ye vision is not distinct, therefore Nature
hath so contrived ye Eye yt it has a power
of adapting itself to neighbor or distant
Obj:ts, for they require a different conformation

of ye Eye because ye Rays proceeding from ye Radiant points of nigh obj:ts diverge more yn those coming fro more dist:ones; but whether ye Change of figure is by ye & ye Chrystalline approaching or moving fro ye Retina or putting on diff:t degrees of convexity is not yet determined; neither is it a matter of very great moment, since either method will serve well enough to explain ye various Phænomena of ye Eye; how it comes to pass ye we see obj:ts erect, wn ye pictures of ym in ye Re-
-tina is inverted, we know not,

Neither did Molyneux or any other,
who attempted to give a satisfactory ac-
-count of it. —— ——

66: Tis ye fault of their Eyes who are purblind
or short sighted yt their Eyes being
too convex uniting ye Rays before they
come at ye retina; wch is to be corrected
by Concave Glasses, wch making these
Rays, wch converge too much diverge
a little so as to meet just on ye retina
or ye Contrary old mens Eyes have their
Chrystalline too flat (ye Humours being
by reason of their drying up)

ey. It cannot either ye divergence of ye
Rays enough to make ym meet just on ye
Retina; but beyond it, yt is easily rectifyd
by convex Glasses

Conjectures abt ye Manr how
Vision is perform'd,

ey How ye Objt represented upon ye retina
Cause in us ye Sensation of Vision,
'tis hard to determine we being not
able to perceive ye Connectio between ye
Ideas & ye Motion whereon they excite
nor even ye possibility of their being any
such Connectio. ye greatest progress we
can make in ~~[illegible]~~ determining ye modus of sensatios

w.ch at length terminate in y.e Agitation of
of Nerves, In our Case 'tis possible y.t y.e
Rays of Light Striking on y.e bottom of y.e
Eye do there excite certain Vibrations
in y.e minute Fibres w.ch compose y.e Retina
& these Vibrations being communicated
by Degrees to the fibres of y.e Optick Nerves
are by y.m propagated, as far as y.e brain;
& tis probable y.t Rays of Light of Diff.t
Kinds excite Vibrations in y.e Brain
of Diff.t magnitudes, w.ch those Vibrations
according to their Diff.t magnitudes
produce y.e Sensations of Diff.t Kinds
of Colours, (as in y.e like Vibrations of
Diff.t magnitudes produce Sensations
of diff.t sounds.)

such Rays as are most refrangible exciting ye shortest Vibrations, & causing ye sensation of a deep Violet Colour; while such as are least refrangible cause ye longest vibrations & excite ye sensation of a deep red. Rays of all intermediate kinds accordingly exciting intermediate Vibrations & causing sensations of intermediate Colours between ye 2 extreams Violet & Red; but of this more hereafter in ye consideration of Colours. — — — — —

68. Wt we have sd. concerning Vibrations in ye Optick Nerves of ye Retina, seems to be Confirmed by ye experimt. — —

for when a Man in ye Dark presses ye Corner of his Eye with his finger, he will see a Circle of Colours like those in ye Peacock's tail, wch seems to arise from ye same kind of motion excited in ye bottom of ye Eye by ye pressure of ye Finger, as at other times are excited by Light for Causing vision. for ye same reason a Blow upon ye Eye makes a man see Flashes of Light. — —

How ye Eye judges of magnitude & dist:

67. The apparent Magnitude of an obj: depends upon ye quantity of ye Pict: upon ye retina; wch again depends on ye Angle under wch ye pict: is seen & is ye Angle wch is formed by 2 lines drawn from ye extremities of ye obj: to ye Eye whose apex determines ye Pict:

70: Dr Hook is of opinion yt ye Eye is not Capa-
ble of discerning particles of ye smallest
ye Microscopical Pores of Wood, because ye
Ends of ye Filaments of ye optick Nerve (on wch
ye discerning faculty depends) are not smaller
yn ye Microscopical pores of wood; so yt any obj.
being remov'd so farr fro ye Eye yt its
picture on ye retina shall be less yn a Mi-
croscopical pore it would be invisible; but
if ye obj. be a very bright one as ye Planets
the whole Filament is moved by having one
pt of it acted powerfully upon whereby
we have a Sensation of ye obj. of ye same
as if it were much bigger. By this reason
Give ye reason why ye fixt Stars appear
to ye naked Eye

Many thousd times bigger yn they really are & why bigger yn wd we se them wth a Microscope.

41 We judge of ye dis. ~~[illegible]~~ by ye Angle & Directiō of ye Axes optici, as we have sd before, for ye situation of ye Eyes, according as ye Axis makes a diff.t Angle, wch Angle de-pends on ye dis. of ye Objt. whence it ap-pears yt by Use we attain a habit of discer-ning ye dist. of Objts by ye direction of ye Axis, wch is sensible to us, because it depends upon ye Motion of ye Eyes themselves,

42 Hence we may see ye Use of having 2 Eyes placed at a certain dist. from one another for as long as ye dist. of ye Eyes bears any

proportion of ye Dist. of ye Obj. we can
judge of it pretty certainly. in great dist.
from unknown Obj: we judge fro
ye apparent magnitude, but it is impossi
ble to judge at great dist. exactly (except
ye same Obj. be view'd fro diff. places)
because ye angle wch in very dist.
Objs are seen does not sensibly diff. fro a
parallelism. hence may be seen also ye
reason why we cannot make a true
Estimate of great Dist. wth both Eyes but.
but of lesser dist. we may in some measure
judge wth one Eye alone provided ye breadth of
ye Pupil bears some sensible proportion of Dist.

43: In short ye apparent magnitude of an obj:
depends on ye bigness of an Angle whose
Base is ye greatest extent in ye obj: &
whose Apex terminates in ye retina
we judge of dist. by ye magnitude of an Angle
whose base is a Line drawn fro ye Centre of
one Eye to ye Centre of another & whose Apex
terminates in some point of ye Obj: viewd,
lastly we judge of ye real bigness of an Obj:
by ye Angle it is seen under in conjunction
wth ye supposed dist: fro those two Rules we
judge of Magnitude & dist. some pre-
-tend to acc. for ye explaining
Phænomena of ye Horizontall Moon.

44. Sr. Observd of ye Sun, Moon & Stars, appeare bigger neer ye Horizon yn when higher elevated though if their Diamtr be taken wth an instrumt the Sun is no bigger in ye Hori-
-zon yn wn in ye meridian: & ye Moon sub-
-tends a less angle in ye Horizon yn in ye Meridian being more dist. by a Semidiamtr of ye Earth. In examining ye most receivd solutions of ye sd Phenomenon, wch I only speak of ye Moon as being more adapted to ye light but ye same hold good in ye Sun & Stars, wee shall consid. first ye solutio drawn from Refraction, ye Lowr. Stratum of ye Atmosphere say they, are much denser yn ye Upper as by reason of their being full of Vapours

as being compress'd by ye Uppr parts & ye
dens. medium refracts ye rays coming fro
ye Moon & increases her apparent magnitude
as wn an obj. is seen thro glass or water.
but tis certain ye refraction in ye Case
cannot at all altr ye bigness of ye Moon;
For since refraction equally respects all ye
points of ye Horizon, whether wthin ye
Horizon wch is but a Circle any where nor can it
be compress'd it be made great in breadth
wthout thrusting some pts out of its
place; otherwise ye reason yt one pt thrust
out another since ex Hypothesi all pts
are eqlly affected by ye refraction. Glasses
indeed represent ye obj. every way enlarged

& thereby hides ye adjacent pts, but in refractions
by Vapours no one pt of ye Horizon can be
expanded in breadth because it canot hide or
thrust out any other pt to make way for it.
75. In ye Altitude it's ordered otherwise; for ye inferi-
-our Limb is more refracted & rais'd higher
yn ye Superiour Limb, wherefore those 2 Limbs
wd seem nearer to Each other & ye breadth of
ye Body contracted, while both ends of ye
Horizontl Diamr being equally refracted &
rais'd keep ye same dist. from one another &
its apparent magnitude remains ye same:
hence appears ye reason why ye Horizontall
Moon appears of an Elliptical fig: whose
largest Diamr is parallel to ye Horizon.

Inshort ye Hypothesis propos'd may be over-turned by one consideration; we're ye appa-rent Magnitude of ye Horizontl. Moon owing to any refraction ye Case wd not at all be alter'd nor its apparent bigness diminished, wn taken by an instrumt. but as wee have already observ'd its apparent bigness wn in ye Horizon is found by means of an instrumt lesse if any yn wn in ye Meridian. As for ye opinion of Gassendus & Hobbes ye one being misled by a very gross Error in opticks & ye other in a point of Astronomy we shal say nothing of em here since they may be seen Confuted at Large in Miscell.

Cur. Vol. 2. p. 263.

wn the Situation drawn from interposed Bodies
we estimate ye height of ye bigness of any Body
say they, not only by ye height it seen undr
but by ye Angle & supposed distance considd
jointly. so if we see objs undr ye same Angle
& at ye same time think one to be twice ye
dist. from us of ye other, we ye more dist.
objt wth first case seem twice as big as ye other.
to apply ye Moon, say they is seen undr ye same angle in ye Hor-
-izon as in ye Meridian (ye diffe being so
very small yt it may easily be neglected)
but in ye former case she appears more
dist; because we compare her wth variety
of objts interposed between us & her wch
present to our Imagination a great
dist. capable of receiving all these — —

wh. tis. are wanting wh. she is in ye meridian the moon though her Angle be ye same yet it appears greater in the Horizon yn in ye Meridian because she is supposed to be at a greater dist. but ye Phœnomenon is not owing to ye apparent dist. of ye Sun bec. Horizon wch. I thus prove 1st because she appears at ye same time of ye same bigness in all Horizons & ye diff.ce of ye apparent dist. never so great. 2dly because at diff.t times in ye same Horizon she appears of very diff.t bignesses. so yt ye Solution contains ye 2 following absurdities 1st It must be suppos'd yt diff.t causes can produce ye same Eff.t & 2dly yt ye same Cause can produce diff.t Effect.

the first Absurdity follows from ye first Argumt; ye Second from ye latter

Why 2 Images formed in ye Eyes produce but one Sensation; when we look at an Object wth both Eyes it wd appear single tho there are 2 Images painted one in Each Eye: some think yt it is occasioned by ye meeting of ye Optick Nerves, before they arive at ye Brain: But ys is mere Conjecture: for ye Anatomists can trace those Nerves all ye way up to ye Brain
* wthout finding any such Concourse.
77 Molyneux wth more reason thinks yt we see Objects single by reason of ye Concourse of ye Axis optici; —

(or 2 pictures made by them in ye Eyes)
but referring these pict.s backwd they are
derived to & determined in a point & there
fore seen as one —— —— ————

48 Hence if an Obj. be placed either wth
out or wthin ye Axes Optic it will in
either case appear double; if it be placed
wthout ye Concourse of ye Axes ye right
hand Image wch is seen by ye right Eye
& ye left hand one by ye left Eye; wch is
thus explained by Molyneux, let both
Eyes be fixt on C & D will appear double
if ye Right Eye B be shut, D will appear
on ye left hand C, being represented by ye
Fig 21. Line D A wch is on ye left hand of C A:
For ye same reason if A be shut & B open

D wch be seen on ye right hand C: so yt if
both Eyes be open D wch appear double
its right Image upon ye right syde & ye
left upon ye left. but if either of both ye
Eyes be shutt, then D wch appear double.
yt if ye right Eye being shutt & ye left Eye
A wch see ye obj: on ye right hand on D
& A being shut, B wch seeth on ye left hand
of D, as it is here represented by ye Line
E B, wch is on ye left side B D; it therefore
both Eyes be open, C wch appear double
so yt its left image wch fall on ye right
Eye & its right on ye left side; ye truth of
wch may be easily made appear by looking
at 2 objects placed at such position & alter-
-nately shutting & opening ye Eyes.

Corollaries.

19 1st. Hence we see ye reason why, wn we
look stedfastly at any obj:, all things
else wch are so appear double: for in ye
Case they must be situated either within
or without ye horopter, in either wch
Cases they must appear double.

80 2^dly Hence also we may acct for Peoples seeing double wn in Liq^r their Muscles being filled & distended wth spirits they arent able to manage ym so as to put their Eyes in a due posture & make ye Axes optici meet exactly at ye obj: they look at.

81 3^dly When ye press either of our Eyes wth ye finger every thing seems double, for ye pressure in straining ye Muscles, incapacitates ym from moving ye Eye so as ye Lines drawn from ye Centre of each Eye meet in a point, wch [illegible] ts claim, there can be no concourse of ye Axes optici.

Scholium.

82 4th From wt has been said Dr. Clarke has found a difficulty in Opticks which

Mr Barrow thought Incurable ye
difficulty in yt Objt seen through a
convex glass appear nearer yn ye eye when
yt is in ye focus of ye glass, since ye rays
diverge & come [illegible] to ye eye from thence; but
on ye Contrary we find yt ye Objt appears
beyond ye point; & we still [illegible] yt ye Image
is really in ye focus of ye [illegible] tho we think
otherwise, as appears from hence; if we make
our Axes of Vision [illegible] any where beyond
ye place where we suppose ye Image to be
it wd then appear double, [illegible] ought
[illegible] as it may be seen; [illegible]
[illegible], it appears yt ye Objt is between ye eye
& ye [illegible]; ye prejudice seems to arise from
hence; we direct our Axes of Vision

or any where beyond it, we canot imagine
between ye Lens and Eye. Hand. out. intercepting
ye Rays coming fro ye Obj.t to [illegible]
Bodies &c. besides, as knowing by experience
ye Globe to be itself a Convex Body we
canot persuade our selves to think it ap-
pears [illegible] a shadowed place, as it really doth,
so knowing by experience ye Obj.t to be behind ye
Lens, we canot persuade our selves to think
it appears before ye Lens. —

Of Light & Colours.

53: Cartesius thought ye Diff. of Colours
were fro ye Diff.t mixture of light,
& shade in bodies, or [like] number &
unevenness, & roughness of their surfaces.
but Sr Isaac Newton has demonstrated
yt Colours are not Qualifications of light.

deriv'd from Naturl Bodies, belonging according to the properties in ye Rays themselves, wch in divers Rays are difft, some Rays being dispos'd to exhibit a red Colour & no other, some a yellow and other; he does not entirely exclude ye Surfaces of Bodies from his theory; for he thinks yt some Bodies are fitted to reflect only rays of some a particular sort, suffocating for ye most pt those of other Colours. He has also discovered that:

Light consists of Rays difft in colours and degrees of Refrangibility.

3d. That Rays wch differ in degree of Refrangibility differ also in colour & to ye same degree of Refrangibility ever belongs the same Colour; ye least refrangible Rays always exhibit red Colours & ye most refrangible,

a deep Violet & all intermediate colours, in a conti-
nued series belonging to intermediate degrees of
refrangibility; & ye analogy between colours
& refrangibility is precise & strict, ye Rays
always agreeing exactly, in both or proportionally
disagreeing in both; ye Species of colour & degree of
refrangibility proper to any particular sorts ~~degree~~ of Rays cannot be
changed by refraction; or reflection from natural bodies
nor by any other cause yet discovered;
for when any sort of Rays hath by means of a
prism been parted from those of another kind
it will ever afterwards obstinately retain its
Colour notwithstanding all endeavours; to
Change it. ye truth of ye foregoing propositions
Isaac Newton has proved by experience
55: first take a piece of paper, cut in ye form of
a parallelogram divided into 2 by a black
Line let fall perpendicularly from one side
to ye other;

Let one half be painted red & ye other blew & ye blew when viewed thro a prism w^th (its refracting Angle of ye prism be illuminated) be raised higher up & ye edge of ye refracting Angle be turned towards ye paper, yt ye paper may seem to be carried lower, ye blew half w^d be carried lower than ye red half, from whence concluded yt ye light wch comes from ye 2 Colours is diff. refrangible, & yt ye blew is more refrangible yn ye Red. — — —

80:— the plane of ye Paper perpendicul. to ye Horizon so yt one colour may be to ye right hand & ye other ye left, close before ye Paper also Candle of ye Colours [illegible] to illuminate ye Colours strongly & a lens [illegible] 6 feet fro ye Paper upon ye floor [illegible]
Larg lens ab. 4.

Inches Diam.r w.ch may collect ye Rays coming fro ye severall points of ye paper & makes ym converge tow.ds so many other points. on White paper held abt ye same dist. beyond ye Lens, ye 2 w.ch are both colours expressd upon ye paper; but one much more vivid yn ye other; & if ye blew be most vivid remove ye paper a little further & ye red will be most distinct, w.ch shews yt ye blew rays are brought to a focus sooner; yt is are more refran-gible yn Red Rays. — —

84: 3dly Let a Stream of sun beams thro an hole in ye window shutter into a dark room & ye w.ch you will find a white Circle, yt is ye figure of ye Sun painted upon ye Wall. transmit ye Light thro a prism (holding its refracting Angle upwards)

yt it would not only appear in ye wall of ye same Colour & height as before, but likewise be changed into an oblong form 5 times as long as before. ye Image wd be terminated wth Rectilinear & parallel sides & 2 semicircular ends, bounded wth sides pretty distinctly but ends confusedly; ye Light there gradually decaying & vanishing. ye Image wd be differently Coloured, ye highest or most refracted Ray being blew wth all ye intermediate Colours down to red. From ye latter expression we may draw ye following Corollarys. —

88. 1st That ye Colours & whiteness are compounded of ye other Colours, for ye image of ye Sun appeared white till ye Compound Rays

of y^d Colour were separated by help of a prism,
thus prod^d. of all sorts by y^e mixt produce a
White; in y^e common instrument of a wheel whose spokes
are painted of diff^t. Colours, w^ch being
swiftly turned round appear all white. For in
deed if it be but slowly turned round Each Colour
w^ll be seen distinctly, there being made a
sensation of all y^e Colours one after another
in a continu^d succession. But if y^e impressions
follow one after another so quickly y^t they
cannot be severally perceived, there will arise
out of y^m all such a Composition as will be
of no particular Colour but have itself
indiff^t. to all of y^m: thus will a burning
Coal nimbly whirl'd round by repeated
gyrations

ye whole Circle appears like fire: because
ye motion of ye Coal is in one pt of ye Circle ye Sensa-
-tion yt it Causes remains impressed, till
it comes to yt pt again. so in a quick suc-
-cession of Colours ye impression of every
Colour remains upon ye Sensorium untill
ye revolution of ye 7 all be compleated
& jointly raises a sensation of ym all wch
is ye sensation of whiteness. ye Diffce be-
-tween white & black is yt white bodies
reflect rays of all sorts very copiously
whilst Black reflects fewer or none. —
89. We may learn also hence to distinguish
simple Colours fro Compound. A simple
or homogeneous Colour is such an one

as cannot by any refraction be split or shatter'd into any other colours; a compounded or Heterogeneous Colour may by refraction of a prism be resolv'd into his original & simple Colours. Sr Isaac Newton proves it as a problem: In a mixture of primary Colours ye Quantity & Quality being given to find ye Compound Colour (opt. 1. p. 2.) There are generally reckon'd 7 original & primary Colours, Red, Yellow, Green, Blew, Violet, orange & Indico: wth an endefinite variety of intermediate gradations. we shall conclude our Theory of Light & Colours wth an experiment to Confirm ye Newtonian Hypothesis of Colours.

As ye oblong Image of ye Sun mentioned
in ye Experimt of ye 87 Sect: wch consists
of divers Colours apply an Obj: of any
Vivid Colour. e.g. Green, Leeke, hold
it to ye Colours of ye figure one after
another & you'll find ye Leek seem to
be of ye same Colour of ye pt to wch it is ap-
-ply'd, e.g. to ye Blew it wll be blue;
wn 'tis to ye Red, Red, but ye greenest or ye most vivid
Colour from whence it appears yt ye diffce of
Colours must be owing to ye diffce ~~of~~ ye Surface
of Bodies; for in ye Experimt we see Leeke
Changes its Colour wthout Changing its
figure or situation of pts 2dly ye all Bodies
are fitted to reflect Rays of some certain Colour
more yn any other though they reflect all sorts
of Rays in some measure wch is ye reason
why of all Colours ye green wth ye mo. Vivid.

We come next to Examine ye 2d Hypothesis to acct. for ye Diff.t Refrangibility of Light. —

¶1. There are 2 Hypotheses brought to acct. for ye Diff.t Refrangib.y of Light, ye 1st supposes yt diff.t Rays move wth diff.t degrees of ve-locity; whereby those yt move swiftest are not so easily diverted out of their way as those yt move slowest, but in ord.r to shew the impossibility of yt, we shall not only prove yt all Rays are emitted wth ye same velocity but yt they are also reflected wth ye same ve-locity wth wch they impinge. ye truth of ye first assertion appears fr. hence. Let. take ye Sun wn just above ye Horizon & supposing him Emitting 2 sorts of Rays each wth diff.t velocities to ye diff.t of Minutes; in ye case ye swiftest Ray coming fro ye Sun wn in ye Horizon comes [illegible],

Seven Minutes before ye Stone [illegible] shew
him in ye position he was in ye Min: before he
could be in ye Eye & ye Slowest Rays coming
ye Min: after, wch shew him in ye same posture
& not at all advanced; so yt by ye End of ye Min:
2 Suns wd be seen over, ye [illegible] opposed diff:
Rays. wch is Contrary to Experience

2dly. He proves yt ye Rays are reflected wth ye
same Velocity wth wch they impinge, from ye
Equality of ye Angles of Incidence & reflectio
(Fig 2) Thus let AC be ye impinging Ray moving
along AC may by ye Rules of Mechanicks be
resolved into 2 other AB & BC (AB being
parallel & BC perpendicular to ye reflecting
plain) Let AB be continued, ye motio
in yt directio is not altered by ye Actio of ye
plane, therefore let BD & DE be equal, ye
Light recede; from ye plane wth ye same force
it fell upon it, ye motio occasioned by ye repulsio
is represented;

by Co-sine of Ang. of Incidence. Now making y^e Angle OCD = y^e Angle OCA therefore y^e Ray is reflected w^th y^e same force w^th w^ch it impinges; whereas if it were reflected w^th a less force y^e Angle OCD w^d be bigger y^n y^e Angle OCA if w^th a greater force y^e Angle w^d be less. —

The Hypothesis supposing diff^t Refrangibility of Rays to arise from y^e diff^t Degrees of attract. but from thence it w^d follow y^t a Red Ray (for Instance) ought to Change it's Colour as oft as it's transmitted thro' mediums of diff^t Densities, w^ch have diff^t degrees of attracti for wheresoever Rays are found diff^tly Refrang they are also diff^tly Coloured; therefore whatever causes a differing Refrangibility of y^e Rays must cause a diff^ce in their Colour; but there it's found by experience y^t a ray passing thro' mediu

of diff.t degrees of Attraction y.t it retains
the Colour, it thence follows y.t ye Refrangi-
bility of ye Ray is not owing to any parti-
-cular Degree of Attraction. —

p. 3 ye 2d Hypothesis Since y.t ye Prod. Specially
presupposing ye Rays to be of diff.t mag-
-nitudes, whereby ye biggest would bee
easily turn'd out of their Course as ye
smallest, yet the amend Hypothesis
hence'd is founded upon a Supposition, w.ch
(Suppos'd being capable of being demonst.d
to be false as ye others are) is rendred
very plausible by ye following

Observations Concerning
the latter Hypothesis.

94. 1st The first of ye Colours Red (wch is ye least Refrangible) strikes ye Eye most forcibly wch appears from hence yt we cannot look long on a Red Obj. wthout pain, any can bear ye green Rays (wch are more Refrangible) doe not strike our Eyes wth so much force; it is therefore wisely ordered by providence yt those Obj. wch we must needs be conversantin are all of yt Colour. —

95. 2dly to those yt are under water all Obj. yt are out of ye water seem to be of a Reddish Colour. for all those Rays reflected from those Bodies yt are ~~being~~ weaker yn ye Red are not able to force their way thro' wth so plentifully as ye Red. for ye same reason ye Sun & Moon wn in their Horizo

Appear of reddish Colours, their rays being transmitted thro a thick atmosphere.

96 3dly The Moon wn Eclipsed seems of a reddish colour, wch is thus accounted for: wn ye Earth is interposed betwixt ye Moon & ye Sun ye Rays falling upon ye Earth's Atmosphere are refracted a little towds ye Moon, but of all those Rays none are transmitted enough, except ye Red, but are intercepted by ye Atmosphere, wherein they are lost; for ye Moon is not Eclipsed by ye dense shadow of ye Earth but by yt of ye Atmosphere. ——

yt Light is not Reflected by impinging on ye Solid & impervious parts of Bodies. 1.

99. It is certain yt ye most fine & polished Bodies such as Glass &c are uneven:

ter Putty & tripoly (made use of generally in polishing of glass) do in scratching merely take of ye largest protuberances & bring it throughout to a smooth grain ye scratching upon it become too small to be discerned: however ye scratchings yt remain are sufficient to cause very irregular Reflections of Light: so yt if Light were reflected by impinging upon ye solid pts of glass, it wd be scattered as much by ye best polished surface as ye roughest.—

98 2dly. If ye Colours made by a prism placed at ye Entrance of a beam of Light into a dark room be successively cast upon another prism placed at a greater dist. from ye former, in such manner yt they are all alike incident upon it;

the 2d prism may be so inclined to ye incident
Rays, yt those wch are of a blew colour
shall be reflected by it & yet ye Red pretty copiously
transmitted. Now if ye reflection be caused
by ye solid parts of ye glass how comes it that
at ye same obliquity & [illegible] wholly impinging
on those parts [illegible] should be all reflected &
yet ye red finds pores enough to be in a
great measure transmitted. —

// 3dly. If ye reflection were caused by ye parts
of reflecting Bodies it wd be impossible
for thin plates, or Bubbles, (at one & ye same
at ye same place to reflect ye Rays of one
Colour & transmit those of another as
(by ye 13th & 15th Observ of ye 2d part of ye Opt
is plain they do, for it is not to be imagin'd
yt at one place ye Blew Rays should hit ye solid

be dark by ye light wch passed ye either ... reflected
[illegible] ye pores of ye body; & yt ye
another place where ye body is either thicker
or thinner, ye one of ye contrary of blew, shall
upon its pores & ye others upon its solid pts.

110 It remains therefore a Question how Light
is reflected, & ye according to these tenets
cannot be effected by ye single points of ye
reflecting body but by some wch are equally
diffus'd, all over its surface & by wch it acts
upon ye Rays at some dist. wthout immediate
contact; & if yt be ye case 'tis the rather
probable yt ye Rays wch do actually im-
pinge on ye solid pts of Bodies are not reflected
at all but stifled & lost in those bodies; for
otherwise 2 sorts of reflections must be
allow'd:— — — — —

it is presently objected agt our first argumt that its
impossible yt any very considerably diffused ~~[illegible]~~
~~[illegible]~~ the cause of ye Reflections of light to be
more regular, since the Asperities in ye surface
of ye body must answer to ye Asperities in ye surface
of ye Body. But it may be replied, (
Supposing ye surface of a body considerably
diffused to be represented by ye fig 23)
here lie plain of ye surface A C [illegible]
[illegible] of [illegible] of a large [illegible] above ye surface
D E H, & C [illegible] ye former surface
must approach nearer a plane than ye latter
as much as ye Radius A B exceeds ye
Radius D B: Besides if these asperities are
supposed to have a less aspect upon it (as ye)
ye more regular yet will ye Reflection be from

of
for by y^e means of [illegible] spaces between y^e E
& [illegible] which in some measure depends
up: so y^t at last y^e surface of y^e [illegible]
[illegible] not [illegible] plane.... —

12. The same holds good in all things whatever,
for let y^m be supposed [illegible] perfect
surface of y^e [illegible]
end in a point at (as some might imagine)
for y^n y^e reflecting force w^d not be eq^lly
disposed; y^e Lines [illegible] exceeding y^e Line [illegible] D
but it w^d terminate in y^e [illegible] of a Sphere
whose Centre is [illegible] y^e Line [illegible] drawn
at right Angles, w^th [illegible] ABE w^ch
represent y^e surface of y^e B [illegible] where
it is plain, y^t y^e Asperities of all [illegible] may
be reduc'd to y^e Case of Spherical ones....

by the a reflecting force exerting itself at some dist. from ye Body, wch not making ye reflections perfectly regul. they will however become much more regul. in fact ye wth out, wch is all we contend for.

Concerning ye Phenomena of ye reflexion of the Rays of Light.

23. The severall Phenomena of reflexion may be brought und. ye following Heads;

1. Thin Laminae of a Bubble of soap wat. blown very thin, or very thin plate of any Pellucid matter, reflect diff. Colours according to their diff. thickness.

2. ye Colours of ye same kind & ord. are much more vivid wn reflected from a thin plate of a denser, yn wn reflected fro a thin Plate or a rarer Medium; thus ye Colours exhibited by a plate of wat. are more vivid yn those exhibited

by a plate of Air, enclosed between 2 glass prisms & more vivid, than if exhibited by a plate of Glass, 3ly y^t density of y^e medium is of the thickness is there requir'd to reflect Rays of y^e same kind & ord^r; 4. That among them there is a ~~medium~~ plate Reflective of all sorts of Rays;

5ly The Colours reflected from a plate of Air are considerably changed by changing y^e obliquity of y^e Eye to y^e reflecting plane, but those reflected from a plane of glass or water are very little alter'd by y^e Alteration of y^e Eye. In ord^r to a more easie solution of y^e Phænomenon we shall lay down y^e Sum of S^r Isaac Newton's Hypothesis relating to y^e Refl. & way of Emanatio: —

104. It is proved by experim^t y^t heat is propagated thro' a vacuum in y^e same manner as thro' y^e Air, as appears from heat of a Thermometer hung in Vacuo,

it wd undergo precisely ye same variatio wth one hung near it in ye open Air. from whence tis plain yt heat is propagated by ye Vibrations of a subtil aether, wch is fine enough to penetrate ye pores of Bodies, & wch Sr Isaac Newton supposes it by its great Elasticity to be expanded throughout ye whole Solar System.

N. 2dly The Rays of Light act upon ye Bodies by exciting some vibrations in them much after ye same manner, as ye vibrating parts or Vibrated in ye Air for causing Sound. but ye subtil Aether being perfectly elastick its vi-brations must be far quicker, yn ye vibrations of ye Air, & ye quickr ye Motio of Light; as appears X its effts. ye vibrations of ye Aether & agitating ye solid particles of Bodies causing

is grown warm, cold, & ye manner Heat may
be communicated from hot Bodies to cold ones
without immediate Contact. — —

100. 3dly as ye Rays of Light Act upon ye medium by
exciting it in [illegible] Vibrations & thereby
creating heat & warmth so according to ye 3d Law
of nature, ye Medium must Act upon ye Rays
of Light by exciting them to be mutually accele-
-rated & retarded, accelerated when ye Vibrations
conspire with ye motion of ye Rays & retarded,
when ye Vibrations run contrary to ye Directions
of ye Rays; — — — —

101. 4thly Since Light consists of Particles differing
in magnitude it follows yt ye largest or least
refrangible Rays must excite ye largest
Vibrations, & vice versâ. & Rays of intermediate
bignesses, intermediate Vibrations. — —

108. Since Bodies attract at certain distances by Refraction of Light & where that attraction ceases, there again begins a repulsive force; that Bodies repel Light appears from Reflection; for reflection is always made towards the denser medium, & that they repel still without immediate Contact, is demonstrated from whence the consequence of it may be plainly proved in Newt. Opt. l. 2. p. 3. prop. 8. we only observe that these sorts of forces act only in contact or at distances infinitely small, decreasing in a far greater ratio than reciprocally as the squares of their distances: whence it appears that the repulsive force must be vastly weaker than the attractive force of the same body, as being at greater distance from it.

Definitions.

109. The Refraction of Light is its being bent out of its [illegible] motion, by its Passing out of one medium into another [illegible] [illegible]

110. Midway between any 2 fits of reflection or 2 fits of refraction (is called ye interval of ye fits) half way between any 2 fits of reflection happens a fit of refraction & vice versa, halfway between 2 fits of refraction comes a fit of reflection, we proceed now to ye solution of ye severall Phænomena laid down above.

Solution.

111. 1. The first Phænomenon is a plain consequence of ye 2d Lemma. for thence it appears yt ye intervals of ye fits must be diff. in diff. Rays but before we come to apply ye theory in ye 1st case, we must observe yt no perpendicular Ray can be reflected from ye ulterior surface of any pellucid medium except it be in a fit of retardation. for since reflection at ye ulterior superficies is caused by ye attraction of ye medium, whereby ye Ray is drawn back again into ye same medium after it was ready for transmission; —

it thence follows yt ye ray being in ye most accurate fit of its motion it will have ye greatest moment & so more easily over come ye attraction of ye medium & break its way through: on ye contrary when it is most unfit (yt is when it is in a fit of reflection) its moment being weakest it would more easily give way to ye attraction of ye medium & consequently be drawn back againe into it & so reflected out of it. yt being premised we suppose ye thicknesse of a bubble equall to ½ ye interval of ye green or mean refrang-ible rays & it will follow yt those & no others would be in a fit of reflection just as they come to ye ulterior surface. for since ye medium is agitated & ye [illegible] of it (which are supposed to be in a fit of vi-bration) [illegible] ye bubble (conse-quently [illegible]) since ye thicknesse of ye bubble is equall to ½ ye intervall of ye fits of green rays, ye green rays [illegible] that [illegible] ye ulterior surface

initio of reflection, & consequently wth Q
reflected & exhibit a ring of green colour.
'Tis certain yt no other Rays can be reflected
at yt thickness, because ye intervalls of theirs fits
are diff. & consequently a[t] other yn green,
wch beginning of reflection either before or after
their arrival at ye illucent surface; ye inter-
-valls are shortest at ye Violet, next in ye Indico,
Blew, green, yellow, orange & red wch last they
are longest of all. Hence ye bottom of ye top
of ye Bubble there must be a black spot in
those or ye [illegible] subsisting of [illegible] ye thickness
is supposed to be less yn 1/2 ye interv. of ye Violet
or most refrangible Rays. consequently
these rays as well as also those must be transmitt.
So yt for want of ye reflect. Rays (of ye top) ye Bubble
must appear insensibly black; not but
yt some few rays wch are reflected, from ye interior
or Exterior of ye black spot. but so few
as to be scarcely discernable;

because (by hypoth.) ye repulsive force is very
weak in comparison to ye attractive force of ye
same Body. ye black spot found in ye rings & those
wch Colours ing? have been mentioned, wch
(viz: next ye black spot at ye top) circle of vio-
-let, ye outer, Indigo, Blue, green, yellow, orange
Red, ye 2d a second succession proceeding from a
second fit of reflection in ye same order. —

112. In ye said body ye Rings of Colours being as
they are viewed distinctly, but it generally happens
yt several Rings are confused & blended together
thereby exhibiting to ye Eye a thing? ...
dilute, compounded Colour wch is nevertheless se-
-parable by ye help of a prism, wch separates ye
Colours ... of wch they were
compounded. ye Confusion of Colours is greatest
at greatest thickness whence it happens yt ye
bottoms of wetting bubbles & ye thickest pts of all
thin transparent plates generally appear whitish
to ye Eye but if lookt at thro a prism several rings
of Colours are easily discernable for a great many
successions. —

113. The ? Solution of ye 2d Phenomenon is obvious

for it appears above y^t ye Colours of thin plates depend upon ye thick^s. of ye ulterior surface. & since ye attrac^n. is strongest in dens^t medi-ums 'tis certain those mediums must reflect ye most Light & Consequently exhibit ye most vivid Colours. —

114: 3^{tly}. The 3^d. Phænomene seems to be owing to ye great^r. density of ye æthereal medium in dens^r. bodies (Contrary to w^t. Sir Isaac Newton sup-poses in his 2^d & 3^d Ed^n. of his Opt. Quer. 19. & 21) whence it happens y^t ye vibrations excited in it by ye Rays of Light must be less (& consequently ye fits w^{ch} they become less) in a dens^r y^n in a rarer medium. The ye dist. between ye fits of transmissio & ye fits of reflexio (y^t is half ye interv^l of ye fits) w^{ch} given or many Authors supposing there to be in air ~~about~~ $\frac{1}{89000}$ pt of an Inch in water $\frac{1}{118000}$ pt of an Inch in glass $\frac{1}{133545}$ pt of an Inch.

115: 4^{thly}. The totall reflexio of all sorts of Rays (coming in fits of reflexion or not) happens at ye ulterior surface of transparent Bodys, w^n ye incid^t Rays so acting to ye surface it follows y^t ye sine of ye angle of incidence is to ye Radius in a great^r proportio y^n ye sine of incidence to ye sine of refraction.

for instance since ye Sine of refraction out of water into Air is to ye Sine of incidence as 4 to 3 [illegible] it follows yt if ye Angle of Incidence, wch ye Ray of Light having out of water be 48°-11 ye Angle of refraction will be 90 [illegible] ye Ray shall be refracted parallel to ye surface of ye water & consequently ye Angle of incidence however so little exceed 48°-11 ye Ray shall be drawn into ye water again & reflected without Comment: & phil. p. 209.

p. 5. In order to account for these Phaenomena we must have recourse to fig. 25 & 26 Let EC be 2 thin polished plates of any [illegible] viz. La plate of glass encompassed wth Air & Ca plate of Air encompassed wth glass; if ye Rays AB & AC fall equally oblique upon them those wch fall at B will be refracted towards ye perpendicular & at C from it according to ye ordinary Laws of refraction, so yt tho BD & bd are equal yet bg will be much longer yn BG & therefore ye [illegible] -ture of ye Ray of Light undergoes a greater change in ye plate of Air yn in ye plate of glass. [illegible] now is ye density & consequently ye attrac. of ye plate of glass {increases ye medium wch surrounds it being ye same

& if ye refracting power be so much increased by ye refracted Rays, whereby ye very ends of ye Circles one shall not visibly diff. there will be diff. Colours of ye same pt. of ye plate wherever Situatio ye Eye is placed in. Graves. Phil. Vol. 2. l. 3 c. 17. — — — Corollary.

119. Hence it appears yt ye diff. of permanent colours in Natural Bodies arises fro ye diff. originally or rather diff. thickness of ye component pts. for since it abundantly appears yt ye Cause wch has been ment. is suff. to produce ye Eff. viz (a variety of Colours) it ought according to ye known Rules of Philosophising to be admitted as ye true cause, hence also it appears yt ye bigness of ye component pts. of natural Bodies may be concluded fro their Colours for if ye pts. of Bodies do exhibit ye same Colours wth a plate of eql. thickness provided they have ye same refractive density (& fro many circumstances it is easie to Collect yt their pts. have much ye same density wth water or glass) to determine ye sizes of those Coloured pts. all we have to do is to find out ye thickness of a plate.

of Glass or a Bubble of water wch exhibiting ye same Colours wth ye particles given. to know how to discover ye thickness of such thin plates of Air water or glass, vid. Newt. op! l. 2. p. 1. obs. 5. 6 7 10. 11. & 12. p. 2. & l. 2. p. 3. prop. 7. we shall conclude wth answering an objection wch at first sight may seem to overturn ye whole Theory.

An objection answered.

118. Agt our 7th Lemma it is objected yt it is impossible ye several diff. sorts of Rays should excite vibrations in ye aether of diff. magnitudes for if ye vibrations made by ye red Rays are longest & strongest of all & those made by ye blew or Violet ye weakest, it follows yt as often as a blew ray happens to fall into such a part of ye medium as is vibrating by a red ray it ought to be affected by these vibrations in ye same manner as ye red rays are &

Consequently its fits ought to have ye same in-
tervals, as ye fits of ye red rays have & ye same
may be R of all other sorts of Rays; for since
they are all less yn ye red Light. Their vi-
-brations ought to be ascribed to ye vibra-
-tions of ye red rays. to wch it may be answered
yt in all probability ye Rays of Light like
most other minute Bodys while one a-
nother &c is never to come &c in such & such
determinate Limits. so yt supposing be true it is
impossible ye Rays of light shd come so near one
another as to fall into each others Vibrations.
& yt is something more yn a Bare suppo-
sition may be proved from experimt. for
According to ye ordinary Rules of Opticks,
a well polisd concave ought to reflect ye
rays of ye Sun into one Physical point
at ye dist. of $\frac{1}{2}$ ye Radius; but on ye con-
trary experience teaches as yt ye focus

has always a very sensible Latitude being in some Glasses ab.t ½ an Inch broad; w.ch seems to arise from an Elasticity of y.e Rays of Light, w.ch w.d not suffer y.m to be too much condensed or brought into too narrow a space. & upon y.e accot tis probable, y.t Light is propagated w.th so great Vehemence fro Luminous obj.ts it being y.e Nature of Elastick particles to recede violently fro those Places, where they are most condensed.

Of Microscopes.

114. Tis y.e Property of convex Glasses to magnify Obj.ts seen through y.m; y.t is an Obj.t seen thro a Convex Lens is seen und.r a great.r Angle y.n w.n view'd by y.e Naked Eye; y.e reason of w.ch appears fro a sight of y.e 28 fig: where y.e Obj.t A B seen by y.e naked Eye is seen und.r y.e Angle

ADE, but if it be look'd at thro' a Lens it will be
seen under ye Angle GLH whereby ye Obj.
will appear magnified & more distinctly. 'Tis
needless to give a farther Explication of ye
fig, after wt has been sd of convex Lenses.
ye magnifying quality of ye convex Lens de-
-pending upon ye refraction of ye Rays as
they go through it, it thence follows yt this is
encreased if ye same circumstances bein-
-creased. ye Eff. may be produc'd by augment.
ye convexities of ye Lens, wch will be more
convex as ye surfaces wch terminate it
are segmts of a less sphere, & ys can only be
had in very small Glasses. such small
Glasses are called Microscopes, by ye help of
wch Objects, wch by reason of their smallness
are invisible to ye naked Eye are vastly

Magnified & very distinctly seen, if it provided ye Obj. be placed between ye glass & ye principle focus; for otherwise ye rays wd be refracted as to intersect & form an inverted spectra on ye other side of ye glass as may easily be deduced fro Sect: 5: 40: case 3d. Circle in wch objs are seen thro ye Microscope is called ye field of ye Microscope. there are also Compound Microscopes made up of 2 or 3 Lenses; thro a Microscope compounded of 2 Lenses ye Obj. appears inverted & much more magnified yn thro a single Mic-roscope. In ys ye smallest Lens (wch is next ye Obj.) is called ye Obj. Glass, ye other ye Eye glass, ye properties of ye Compound Microscopes we shall make ap-pear very much resemble those of Telescopes. ——

120. A Telescope is an Instrument fitted to see dist. objts wth this made wth a long tapering tube having a Convex glass in Each End, ye biggest is called ye Objt glass, & ye less ye Eye glass, because ye Eye is applied to it, these glasses are so placed yt their foci may meet in one point: suppose ye telescope be 10 feet long ye focus of ye Objt glass 120 Inches from it & ye focus of ye Eye-glass wth ye Objt 1 Inch. —

121. There are 3 sorts of Telescopes, ye 1st is called Galileo's Telescope & consists of a convex Objt-glass AB (Fig. 29) & a concave glass CD so placed yt both their principal Foci may coincide in ye point F. this is plain fro Sect. 48 Case 4th. yt all parallel rays (for these are in a Physical sense wch proceed fro very dist. Objects) shd converge to ye point F. but by Sect 49 Rays converging to F

shall by ye Concave Glass be refracted par-
allel; therefore ye Sect. 125 Vision will be
distinct. Objects shd appear erect thro ye
glass because there can be no intersection
of ye Rays as is plain fro ye Construction of
the figure &c. —— ——

128. The 2d sort is calld ye Astronomicall
telescope; being used only in Astronomick
Observations it Consists of a Convex Objt
Glass AB (Fig 30) of a very large radius
& of a convex Eye-glass CD of a very small
one so placd yt both their foci may meet
in F. ye Objt glass wd form an inverted
representatio of ye Objt like yt in ye Camera
Obscura at F. fro whence ye Rays at Each
point wd be thrown parallel upon Each
Eye & visio would be distinct. but ye Objt
must appear inverted because ye rays
intersect at F. —— ——

123: The Common day telescope consists of a convexe Obj.t glass (Fig. 31) ABC 3 convexe Eye-glasses CD, ED, GD, so placed yt ye foci of ye 1st Obj.t glass & Eye-glass may meet at F & let F be ye point where ye foci of ED & GD concur. tis plain yt ye Obj.t glass wd form an inverted spectrum at F, fro whence ye Rays of each point wd be thrown parallel upon ye Eye-glass ED & then again wd be collected into ye point & where there wd be formed another spectrum like ye former and Erect (because ye rays cross again & consequently invert ye former spectrum) fro whence ye rays proceeding fro each point wd be thrown parallel upon ye Eye & thereby vision wd be rendered distinct & ye Obj. wd appear Erect, for ye Immediate Obj. of Vision is ye Erect spectrum &c.

124 There are 3 ways by wch telescopes may assist ye Light, 1st by making ye Obj. clearer, yt is done by ye help of ye Obj. glass: for it being much larger yn ye Eye a great many rays are cast into ye tube,

and is carried to ye Eye, wch would otherwise have
your evil: so yt ye remaining more satisfyd
must needs appear cleare —

125.2. 2ly by making ye Obj more distinct, wch is eff.
by means of ye Eye-glass for rays coming fro
ye focus of ye Object glass wch an Inch dist. fro
ye Eye-glass are carried to ye Eye diverg
-ing, & they cd not be brought to a focus in
ye Retina, were they not so refracted in
passing thro ye Eye-glass as to be carried
fro thence to ye parallel ye Eye being natur
-ally to bring parallel Rays to a focus on ye
Retina. yt they must be carried to ye Eye
in parallel lines after transmission
thro ye Eye glass, is manifest. for parallel
Rays wd be brought to a focus at an Inch
dist. fro ye Eye-glass, therefore e converso
Rays coming fro ye focus, wn refracted by ye Eye glass,

w^ch move in parallel lines. & all w^ch perhaps (when y^e focus of y^e Ob^t glass & of y^e Eye-glass coincide), & it may be und^d y^t since y^e focus of y^e Eye-glass is y^e point fro whence Rays passing thro y^e Eye-glass are brought to a focus on y^e Retina; were y^t point further from or nearer to y^e Eye-glass, y^e Rays w^d diverge either too much or too little to come to a focus just on y^e Retina.

120. 3dly Telescopes assist y^e Light & magnifying y^e Obj^{ts} for y^e Appar^t Diametrical bign^s of y^e ~~[illegible]~~ Object seen thro a Telescope is to y^e Appar^t Diametrall bigness of y^e Ob^{ct} seen by y^e naked Eye at y^e Station of y^e Ob^t Glass as y^e focal Length ~~length~~ of y^e Ob^t glass is to y^e focall Length of y^e Eye-glass. in demonstrating

fig 3^d. y^e proposition we shall speak only of such Rays as pass thro y^e Centre of y^e Obj^t.

Glass & Consid.r but ½ y.e opp.l Angle at a
line & [illegible] therefore x, y, z be an
Obj. glass of y.e focal dist. xy, & y, h, l, an
Eye-glass of y.e focal dist. n l, & y.e [illegible]
Obj. A B C w.ch proceed. in inverted posit.
at R, [illegible] [illegible] & Z, each of them,
& draw [illegible] 6 Z, now let us
suppose y.e Naked Eye at h [illegible] point
f & d shall appear und.r y.e Angle f h E;
but if y.e Eye view it from o through telescope
it w.d appear und.r y.e Angle G o h; w.ch by reason
of opp.l is eq.l to f h E w.ch also by y.e construct.
of y.e figure is eq.l to f g E but by Geometry
f g E : f h E :: [illegible] y.e again d y b [illegible] Angle
und.r w.ch y.e Obj. appears to y.e Naked Eye
at y.e Station of y.e Obj.-glass [illegible] is [illegible]
f h E . e.g. to z h, & f g. E to g o h, therefore
o h : x y b :: y E : h E : [illegible] thus suppose
y.e focal length

of ye Obj. be 12 feet or 144 Inches & of
ye Eye-glass but 3 Inches, yn ye apparent
Diamr of ye Obj. seen thro ye glass is to ye
seen by ye naked Eye as 144 to 3 or as
48 to 1 wherefore such a telescope will
be magnifie 48 times. — — —

We now proceed to give some reasons
why Telescopes cannot be improved
in infinitum. — —

124 There are only 2 Ways of improving Telescopes
either by making ye Obj. look clearer
or greater. There's but one way to make
it looke Clearer; yt is by enlarging ye Obj.
glass now we find yt a lens of above 30°
will not refract all ye Rays yt fall upon it,
into a focus; but so much of ye lens as
Exceeds 30° will refract ye rays diff.
fro ye other ptts whereby ye Obj. will be —

rendred confused, wherefore at ye same time 245
we magnifie ye Obj. we must lessen ~~ye~~
ye convexity of it so yt its surface may
not exceed an arch of 30°. but tis a very
diffct matter to grind large surfaces wth
small convexities. nevertheless. ——

128. 2dly granting ye Obj. done yt Eye is
not able to bear so great a Quant. of Light
as wd yn be admitted, wch is ye reason
why telescopes of diffct apertures ought
to be used to look at Objts at diffct dist.
thus tis not proper to look at ye moon
wth ye same telescope yt look at Saturn wth.

129. The other way of improving telescopes
is by magnifying Objts. since Objts
seen thro telescopes & wth ye naked Eye
are to one another, as ye focal dist. of ye
Obj. glass & ye Eye-glass one wd think ye
ye dist. being increased ye Obj. wd likewise
be increased;

wch might be done either by doubling ye dist. of ye Obj.-glass or by diminishing making ye focus of ye Eye-glass as little again & yn ye Obj. wd appear as big again as before. wch being carried on ad infinitum ye Obj. must be magnified ad infinitum. To wch it may be answered yt ye Diff. of ye focall dist. [illegible] neither [illegible] or increase but by diminishing ye convexity of ye Obj.-glass or by increasing yt of ye Eye-glass. ye former way wd make ye Obj. more & more obscure; & ye latter we have proved already to be limited on acct. of ye frangibility of Light. —

160. But tho no farther improvemt of these instrumts can be made ye Dioptrick way yet Mr [illegible] is of opinion yt by ye help of reflections, telescopes may be brought to almost any degree of perfection;

our

if we c^d but find a reflecting surface y^t w^d polish as fine as glass reflect as much as Light as Glass transmitts & be formed into a paraboliciall figure. y^e tube of w^{ch} it is made must be open at y^e End w^{ch} is towards y^e Obj^t y^e other end close, in w^{ch} is to be placed a Concave Metalline Speculu & near y^e open End there's a flat open Speculu made as small as may be y^t it's lest obstruct y^e entrance of y^e Light into y^e tube (i.e) & inclined tow^{ds} y^e upper end of y^e tube where there's a little hole furnished w^{th} a small plane convex Eye-glass. so y^t y^e Rays Coming fro y^e Obj^t do first fall on y^e concave placed on y^e bottom of y^e tube, & are thence reflected tow^{ds} y^e other End of it, where they meet w^{th} a flat Speculum obliquely posited by y^e Reflection of w^{ch} they are reflected to y^e Little plain convex glass,

& colours wch looking downwards sees ye obj[illegible] wch ye telescope is turned &c. ye Instrument is described more at large in Newtons Opticks b. 1. p. 1. prop. 7. we shall conclude wth an acct. of ye Rain-bow. — — — — — — —

131 All rays of Light issuing fro a point in ye Sun & falling upon a drop of Rain are Physically parallel i.e. to all sensible appearance: just as 2 plummets tied to 2 strings wch hanging down seem to be (exactly) parallel, tho in reality they are not so, for both gravitate to one point, yt is to ye Centre of ye Earth, where if they were produced they wd meet together & Consequently they are not Mathematically parallel. ye same happens to Rays wch are emitted fro ye Sun, wch is ye reason we can never judge of his true dist. or Magnitude; if all Rays flowing fro a point in ye Sun & passing.

that a drop of Rain some only are propr to re-
-present ye Image of ye sd point, after emersio,
to ye Eye: namely such as come out parallel
& to distinguish ym fro ye rest they are all usually
call'd Efficacious Rays: for supposing any
to consist of a great many Fibres entring
a Sphericall drop of Rain & diverging
after egression, ye consequence wch is yt
they wd not enter ye Eye but fall beside it,
on ye other hand let us suppose some to
converge, ye Eye not being plac'd in their
Converging focus wd miss them: but suppos-
ing some to come parallel, as indeed they do,
ye Eye being adapted to bring parallel
Rays to a focus on ye Retina, wd have
ye Image of ye Sun painted upon it at what
dist. soever ye Eye is plac'd, all Efficacious
Rays falling upon a drop of Rain,

wth such a degree of obliquity as yt ye Emerging Rays shd after one reflection make an Angle of 42° wth ye Incid. ones and after 2 reflections an Angle of 50° & thus shall there be made 2 Bows an Interiour or Primary & strongr one & an exteriour or Secondary one & faint for ye Light becomes faint by every reflectio.

132. This Philosophy or Geometry is confirmd by an experimt. of a glass globe hung up in ye Sunshine & filld full of watr: for if ye view it in such a posture yt ye Rays wch come from ye globe to ye Eye may Contain with ye Suns ray an Angle of 40° ye Spectator wll see ye red colour on ye side opposit to ye Sun. if yt Angle becomes less there wll be seen other Colours as yellow, green, blew, &c. If ye Angle be 50° there wll appear again red colour — — —

& if ye Angle be made greater there wd be
other Circuits as necessary [illegible] but ye
Colours wd be inverted. ye same may be
done by letting ye Rays not Passing
& Dispersing ye Light make such changes.

133 The fig. of ye Primary Iris explained
upon a supposition yt ye Sun is but a point
& yt ye Rays of Light are all equally refrangible:
fig. 13. Let us suppose ye Sun at S emitting
ye Rays of Light SE, let us likewise
suppose E a drop of Rain on wch ye Ray
SE falling shd after one reflection & 2
refractions be carried to ye Eye plac'd at O.
Let us also suppose ye Axis as per his
(wch is a Line drawn fro ye Eye thro ye Center of
ye Bow)

OP parall. to ye Incid.t Ray SE to make an
Angle of 42 degrees wth ye Emergent Ray
EO, ye Angle of OES is likewise an Angle of
42d for ye supposition yt Lines SE & OP are
parallel & by ye Rules of Geometry. ——
A Line cutting 2 parallel lines wd make
ye Alternate Angles Eql. (viz: POE & OES)
but it is granted yt ye Ang. POE is an Angle of
42d, therefore ye Angle OES must be so
Likewise. Q.E.D. —— ——

134 Now let us suppose ye Angle EOP to be
revolved about ye Line OP as upon its Axis &
it wd generate a Cone having OP for its
Axis. & if ye Periphery of ye Base of ye Cone
be full of drops of Rain there wd be formed
a Bow of a red Colour; —— —— ——

for these are ye only Rays wch after one re-
-flection & 2 Refractions make an Angle of 42°.

135. having thus found out ye Largest Bow ye
primary Iris we may easily determine its
Diamr: for ye emergt ray wth ye Axis aspect
-us forms an Angle subtended by a Line wch
Semidiamr of ye Bow of 42°; so then it will
follow yt ye double of yt wch is ye Diamr wch
Contain 84° & thus ye Apparent Diamr
is discovered.

136: The Angle of 42 being ye greatest in wch
ye least refrangible Rays can Emerge
after one reflection out of ye drops of
Rain & strike ye Eyes wth ye deepest
red: By ye same argumt it will follow

ye Rays wch have greater degrees of Frangi-
-bility shd appear every one in their ord[er]
below ye Red as ye degrees of Refrangibility
require; as first orange, ye yellow, green
blew Indico & Violet, but ye Violet for ye
mixture of white Light in ye Cloud wd appear
faint & incline to purple - & so whence ye bow
in ye Clouds takes its breadth & Colours.
134. The breadth of ye primary Iris Sr Isaac
Newton found to be 1°.45′ supposing ye Sun
to be a point, but wn he consider'd him
Consisting of Infinite points. he found
yt ye Breadth of his Body ye Bow wd in-
-creased $\frac{1}{2}$ a degree & so ye breadth of ye
interiour Iris 2°. 19 . — — — —

138: The primary Bow is never seen wch ye Sun is
Elevated above 40 d. Above ye Horizon, wch ye
Sun is in ye Horizon one Axis aspectus
being in ye Centre of ye Bow it follows yt
we can see just ½ of it, but wn ye Sun is
Advanced higher, ye Axis aspectus being
more Elevated & Coming nearer to a per-
-pendicular ye greater part of ye Bow will
be hid undr ye Earth & consequently ye less
will be visible; wherefore having ad-
-vanced farther yn 42 degrees ye Bow
is never seen unless to one elevated
pretty much above ye Earth or yt ye
Bow will appear greater or less in
proportion to ye Elevation of ye Eye. --

139. No 2 Persons can ever see ye same Bow because ye Emergent Rays make certain Angles with ye Axis Aspectus, but every Man hath not ye same axis Aspectus, therefore 2 Persons cannot see ye Same Bow. Thus. ye Rays wch are refracted thro: certain drops of Rain; come to one persons Eye & not to another, because one is in a position to receive em & another not, & consequently one cannot see ye same Bow yt another does. Concerning ye secondary Iris see Newt. opt. l. 1. p. 2. prop. 9.

Of ye Prolateness of ye Earth.

1. The Earth is of a prolate Sphæroidical fig. Like a Bow, as may be proved —

To find ye Centre of Oscillation.

as ye Lenth of ye String is to ye Semidiam of ye Bell so is ye Semidiam of ye Bell to ye [illegible]

viz: from ye inequality of ye Meridional degrees. for ye Equatorial Diamr is 34 Miles longer y.n ye polar, ye degrees of ye Meridian growing long & more weight tow.ds ye Line. for ye proof of wch divide ye heavens wth Circle fro pole to pole into Equall pt., ye divide a little Circle of ye Earth after ye same manner & youll find Eqll pt. of ye terrestrial Circle wch incl. ye par.ll to eqll pt.s of ye Celestial. whence we infer ye ye fig: is not Exactly Spherical: because if it were it wd be so portionably answ.d to ye other Circle wch is Sphericall;

2. A 2d Argumt to prove ye Earth a prolate Spheroid is taken fro ye oscillation of Pendulums. Suppose a Clock goes true in Denmark or Sweden being tto

ye Equr & it wd be too slow: Being itto ye Poles & it wd be too fast: Mons. Jarques fd ye Vibrations at ye Equator are slower yn at ye Pole, & as gravity is ye Cause of Vibrations he concludes yt ye Gravity of ye Earth is less at ye Center of ye Equator yn at ye Poles, ~~consequent~~ & consequently yt if ye Equator are farther dist. fro ye Center yn ye poles from it by wh it appears yt ye Earth is not Exactly Spherical.

3. A third Argumt is taken fro ye Suns Course in ye Ecliptick & its cutting ye Equator. ye Ecliptick is divided into 12 Signs. Aries, Taurus, &c. In Ptolemy's time ye Ecliptick cut ye Equator at ye Aries & Libra ye 2 oppo-site Signs. 40 years after it did recede one & cut it in Pisces & Virgo; fro ye reas-ion ye Earth is concluded to be a Prolate

5.° quomodo pro lata Telluris figura constet
ex unico Parallelo haud mihi adhuc apparet

Spheroid not an oblong wch instead of re-
-ceding wd proceed But if ye Earth were
a perfect Sphere there wd be no such change.

4 We must next enquire into ye Cause of ys
prolate fig. yt wd follow fro those sup
-positions viz: yt ye Earth was at 1st a fluid
Mass & after became consistent; or yt
it is still a fluid; & wt we tread upon is
only a Crust. — — —

5. Whether upon a supposition of ye Earths
primitive fluidity its present fig. is
easily accted for because every ptcle eqlly
attracting all pts must necessarily
gravitate towds ye Centre of ye Mass,
& consequently form ym selves into a
Spherical fig: & ye Earth being a prolate
Spheroid is a confirmatio of ys Hypothesis;

A fluid planet without motion wd reduce it self to an exact Sphere; but wth ye motion abt its Axis commensurate fig. must necessarily Change. if ye Earth moves abt its Axis ye moving pts describe Circles & endeavour to recede from their Centre, whence it follows yt ye Centrifugall force is greater abt ye Equatorial pts yn abt ye Polar because pts are opposed more to ye Centre of gravity yn ye others, they moving only in Lateral directions hence we infer yt ye Earth was created in a State of fluidity must necessarily by ye motion abt its Axis be Spheroidicall. no doubt but God might create it in a Sphe-roidicall fig. therefore no great Stress is to be laid upon this Argumt; only so far as we may suppose,

w^ch after he had Created it he left y^e guiding of it to 2^d causes. again, who knows but y^t w^ch we tread upon may be a Crust & y^e rest a fluid for no body ever dug so deep as to discover.

6. A 2^d may be taken from y^e pres^t constitution of y^e Earth, y^e p^ts towards y^e Center are dens^r y^n at y^e Surface w^ch is plain from experience & reason. By experience we find y^t y^e deeper we dig Mines y^e Earth is y^e Dens^r. & reason tis manifest y^t every p^t s^d take its place according to its specifick gravity w^ch position co^d not be eff^ted unless y^e Earth w^r primarily a fluid: but y^e p^ts of y^e Earth are dispos'd

according to their Specifick gravity wch
tis probable yt it was at first a fluid.

7 A third Argumt is taken fro ye comparison
of one planet wth another) v. Hydrost. lect.

8. Anr from Calculation.) 36 : 34.

9. Anor Argumt fro ye fig: of ye Moon supposing
it oblong but there cannot be much stress
laid upo ye Argumt because it has been ob-
-served ye figr is not such.

10 Anor Argumt fro ye motio of rivers viz,
if ye Earth wd at first a fluid sphere, a ye pt
of it wd gravitate towards ye Centre so great
deal of ye Polar watr wd run to ye equator
& ye watr rest in equilibrio; if ye increase
ye Motio of ye sphere more watr at ye Poles
wd run to ye Equator if ye diminish ye motio

it w.d return to ye Poles; hence we Conclude if ye Earth had a greater degree of prolate-ness, ye Rivers w.d run into ye Poles; if less to ye Equator.

11 The End & use of prolateness of ye Earth is that ye Earth may continue its motion about ye same Axis; for if any thing c.d alter ye pres.t prolateness of ye Earth it w.d make a diff.t Axis, hence we s.d have diff.t Latitudes E.g. Cambridge w.ch is now ab.t 52.d from ye Equat.r, if ye Axis were changed might be perhaps 53.d or 54.d suppose a mountain s.d arise in p.t of ye Earth 3 miles high (w.ch is ye greatest height of Mountains) ye Mountain w.d endeavour to get to ye Equator, & change ye Axis: But as ye Equator is 34 Miles higher y.n any other p.t of ye Earth 'tis sufficient to keep of ye p.t of this Mountain.

\+ N.B. ye Eccentricity being added to ye mean distance w.d give ye planets greatest dist. & vice versa, being substracted from it, its least distance.

Astronomy.

1 Astronomy is ye Science wch explains the motions of ye Bodies wch compose our Planetary Systm & ye Phænomena thence arising, ye Bodies are in Gen.l ye Sun & ye planets revolving round him & pri-mary & secondary. we shall first form a gen.l Idea of ye situation of ye primary planets wth respect to one another & wth respect to ye Sun in ord.r to wch it is ne-cessary to premise ye following definitions.

2 The planets move in Elliptical orbits & placed wth respect to ye Sun, yt one of their foci coincides wth his Centre; whence there's always a certain dist. betwen ye Centre of ye Sun & ye Centre of ye planetary Orbit; wch dist. is call'd ye planets excentricity. 3dly in every revolution ye planet must once approach to

once round ye Sun. ye point of its
Orbit in wch it is nearest of all to ye Sun
is called ye Perihelion ~~Aphelio~~ & ye point wherein it is farthest
off its Aphelion these are sometimes known
by ye generall Name of Apsides or Auges. —
A Line passing thro both of em is called ye
Linea apsidum. A planet is at its mean dist.
wn it is at ye point of its orbit wn either side
is equall dist. from ye Perihelion & Aphelion.
ye orbit of every planet produced makes a plane
passing thro ye Centre of ye Sun but they are
diff. placed wth respect to each other;
the plane of ye Earths orbit is called ye plane
of ye Eclipt. wch astronomers suppose to be
continued ~~extended~~ every way. & wth resp. to ys they
Estimate ye position of ye planes of ye orbits;

of ye rest of ye Planets. The points in wch ~~these~~
these intersect ye plane of ye Eclip. are call'd
ye Nodes. A line passing thro these is call'd ye
Line of Nodes. The Planets all move in their
Orbits ye same way viz. Eastwd & a motion in ye
~~this~~ direction is sd to be direct or in consequentia &
a contrary motion viz. Westwd is call'd a motion
in antecedentia or Retrograde Motion. A line
passing thro any planet & abt wch it moves
is call'd ye Axis of ye planet; the extremities
of wch Axis are Call'd ye Poles.

3 From these laid down we may get a pretty exact Notion
of ye planetary System & of ye following Table
wch shews in ye 1st Column ye Characters & also
ye Astronom. names of ye sevl planets, in ye 2d
their mean dist. fro ye Sun; in ye 3d ye eccentricity

Of their Orbits in ye & their inclination of their orbits to ye plane of ye Ecliptick in ye [illegible] their Annuall, & their diurn: Rotation, in ye last ye No. of Secundaries revolving round em.

	1	2	3	4	5	6	7
Names	Charac=ters	Mean Distances	Eccentri city-	Degrees of inclination to ye plane of the Ecliptick	Periodi-cal Revolu=tions	Diurnal Rotations	No. of Satellits or Secundaries - -
Mercury	☿ ☿	387	80	6°: 52′	87d: 23h: 0′	uncertain	0
Venus	♀ ♀	723	5	3°: 23′	224d: 17h: 0′	23h: 0′: 0″	0
The Earth	⊕ ♁	1000	169	0°: 0′	365d: 5h: 51′	23h: 56′: 4″	1
Mars	♂ ♂	1524	141	1°: 52′	686d: 23h: 0′	24h: 40′: 0″	0
Jupiter	♃ 4	5201	250	1°: 20′	4332d: 12h: 0′	9h: 56′. 0″	4
Saturn	♄ ♄	9538	547	2°: 30′	10759d: 7h: 0′	Uncertain	5

Scholium 4th.

4 That there are 6 primary planets we are certain, bt we are not certain yt there are no more; our not being able to discover more is no Argument agt ye conjecture, for neither can ye Inhabitants of Mars (if there be any such) see Mercury; nor those of Jupiter & Saturn see any of ye inferiour planets, but one or another; therefore it is no way unreasonable to suppose yt there are planets between Mercury & ye Sun, wch cannot be seen here by reason of their nearness to ye Sun, but yet might be seen by ye Inhabitants of Mercury. Mercury can seldom be seen by us in ye Horizon as he now is, & were he a little nearer to ye Sun wd be always invisible to us on Earth, for ye same reason he is now to ye Inhabitants of Mars.

And in generall ye Rule obtains yt ye inferiour
planet is visible to a superiour one yt is 3
times further dist from ye Sun yn itself.
thus ye dist of our Earth is to yt of Mercury
in round Nos. as 10 to 4 but were it as 12
to 4 or 10 to 3 Mercury wd be always
invisible to us. — — — — —
It may be Objd yt were there more planets
between us & ye Sun they wd sometimes
appear as spots in ye Sun; but it may
be answd yt Mercury ~~himself~~ is so small
as scarce to be Visible; & if there be any
other planets they are ex hypothesi
nearer to ye Sun yn mercury & consequently
Invisible, Besides tis generlly observd
yt nearer any planet is to ye Sun ye less
is its Body:

thus Mercury is less yn Venus, Venus yn ye
Earth & Moon; so yt its possible yt planets
nearer to ye Sun yn Mercury have less Bodies
yn he, tho yt reason is not conclusive; for
Mars tho he be beyond ye Earth is yet
less yn it, & tho Mars be less yn Jupiter
yet Jupiter is bigger yn Saturn, tho yt
planet is farther dist. fro ye Sun yn Jupiter.
Vid: Bak. Refl. p. 113. — — — —

Scholium ye 2d.

6 We have little reason to doubt but yt ye
other planets are inhabited as well as
our Earth & it is also reasonable to sup-
pose yt ♃ & ♄ are inhabited by more ex-
cellent Creatures yn our Earth as may be
Concluded fro ye largeness of their Bodies

A Novelty of ye Earth & ye great expence Nature has been at in providing ye one wth 4 ye other wth 5 Moons, wch she has given ye Earth but one to attend her. & upon ye same acct it may not be altogether unreasonable to suppose ye other planets to be inhabited by less excellent Creatures their Bodies being less yn ye Earths & they having no moons to Attend ym. Cassini had twice a Sight of something very like A Satellit or Moon of Venus but cannot Confirm ye discovery by any new views of it. Decouverte de la lumiere. p. 45.

Scholium ye 3d.

7. Tis Observed yt ye following rule obtains throughout ye whole System: viz. yt ye

Squares of ye periodicall times are as ye Cubes of ye Dist. of ye planets one to another frõ ye Sun. If you wd try any of ye planets by yt Rule you must be very Exact in taking both ye Dis. & ye Periodick times: for if they be taken in round Nos as they are delivered above ye Rule wd not hold good; but if they be taken very Exactly (as they may be found in Newtons Principia at ye latter end of ye 3d Book) it wd never fail ei-ther in ye Primary or Secondary Planets. thus Suppose $\frac{1}{2}$ to be ye Periodical time of ye ⊕, 4 of ♂ & 10 ye dis. of ye Earth: ye may find ye dis. of Mars frõ ye Sun by squaring 2 & 4 & by cubing 10. thus $2 \times 2 = 4$. & $4 \times 4 = 16$ now I say 4 : 16 :: 1000 : 4000 ye take ye Cube root of 4000 = 15 in a round Nor wch is ye Dis. of ♂ & you wd find yt ye Cube root bears ye same proportion,

observations

is ye periodick time of Mars as is ye Cube
root of roots of ye Periodic time of ye Earth.
before ye various Phenomena arising
fro ye Planetary Motions can be ex
-plain'd it wd be necessary to lay down
some precautions abt real & apparent
Motion wch can't be done wthout premising
something abt ye dist of ye fixt Stars;
8: Huygens in his most exact Astronomical Cal
-culations cd never discovr any visible
magnitude of fixt Stars: tho he us'd glasses
yt Magnified ye Diamrs apparent above 100
-times; Now since ye fixd Stars Shine wth their
own Light they are in all likelyhood Suns
Each having its Planetory System abt it

like our Sun. & we may at a reasonable me-
dium suppose yt they are abt as big as our Sun:
some perhaps being bigr some less; let us n
for Example suppose ye Dog star to be of
ye same bigness wth ye Sun, ye Star by
reason of its vast distce tho it be view'd
thro a telescope magnifying an 100
times) appears of no ~~...~~ real magnitude.
now we must esteem it subtending an
Angle of less yn 10'' to appear at no
definite magnitude; but at a point.
ye Sun at present only subtends ye Angle
of 32'. therefore lets move the Sun
to such a distce as yt he may subtend an Angle
of less yn 10'' we must Multiply 32 by 6

because there are 6 × 16 in a Minute w^ch produce 275
32. But if y^e Multiply 192 y^e Suns dis^t.
100 times w^ch may be done by y^e best possible
copes & yet there w^d be appear no big^r. y^e seconds
ing to y^e way of proceeding he must be at y^e
Dis. of 100 × 192 = 19200. therefore y^e
first Stars are at least 19200 times as far dist
from us as y^e Sun is & perhaps a great deal more,
y hence it appears y^t even y^e whole annual
Orb^t. of y^e Earth can appear of no sensible
Magnitude to y^e dis^t. of some of y^e fix'd Stars
& consequently w^t soever y^e of its revolution
it w^d always keep y^e same sensible dis^t. w^th
respect to y^e first Stars: it w^d be expedient
to lay down some precaution
Concerning y^e Appearance motion & place.

10. The Chief diff. we find in forming y^e true Ideas of y^e Planetary System seems to arise fro y^e prejudices we have contracted fro y^e Apparent & Imaginary motions of y^e Heavenly Bodies; for we can Observe very little in y^e Heavens but false Appearances; therefore as it is one of y^e Ends of Phylosophy in gen^ral to take away those prejudices arising fro y^e outw^d appearances of things, & to consid^r realities abstracted fro those false appearances; so it is more p^rticularly y^e work of Astronomy to rectify those false judgm^ts our senses are apt to make ab^t y^e various motions, dis^t & magnitudes of y^e Heavenly Bodies; it w^d be for y^e want of these Considerations y^t some of y^e Ancients laid down such gross & inconsistent schemes

Of Astronomers neglecting entirely ye simplicity of ye System, & analogy of Motions; but to return —

11 Tis plain fro ye rules of Opticks yt we can only estimate ye motion or rest of any Body by means of ye Pictures on ye botts of ye Eye; if ye pictr changes its situations we conclude ye body has movd wth such a velocity & direction; if ye picture remains in ye same place we conclude ye body has remaind at rest all ye while; tho in both cases we may be deceivd. for

12 If ye Pictr changes its place only on ye Retina tis impossible yt we shd know whether yt Change is effd by a Diffl positio of ye Eye or ye Body; for ye same appearances wd happen whether we move our Eye & ye Body at rest or ye Body be moved fro ye Eye at Rest. yt Sailors every Day experience, for as they sail along any Shore-

the Ship seems to be at rest & ye Shores to move a long. —

13. we may easily be deceiv'd, w^n ye Diet of any Body keeps ye same situation any relina; for ye same appearances wd happen whether ye Body doth really rest or whether ye Body & ye Eye are both mov'd together wth eql velo-cities, & in ye same direction. wch also sailors can testifie; for wn 2 Ships sail along wth eql swiftness to those on board ye 2 Ships seem to be at rest whilst ye Shores run along. —

14. As ye Eye often errs abt ye motio of Bodies, so also doth it make a wrong estimation of ye places of Bodies. thus ye Heavens are nothing but im-mense Space & Vacuity & wd appear black were it not for innumerable white rays of ye Sun penetrating our Atmosphere; so yt while we look at ye black skye, ye white Rays of ye Sun ent'r our Eyes, whence ye blew colour of ye Sky arises. But because wt we e

be. as a Colour we are used to refer it to a Colour'd 279
Objt; we also refer ye Colour of ye Heavens
to a real Opake objt, Imagining ye Heavens
a concave Surface (in ye Centre of wch we are placed)
situated far distt beyond all sensible Objts.
15. To ye Imaginary Concave Surface we refer
ye places of all Celestial Objs Bodies, wch are so far
removed from us yt we can give no judgmt.
of their distt so yt they all appear to be equally
distt & seem to move in ye Surface of ye same
imaginary Concave Sphere, wch may not
improperly be term'd ye Sphere of ye fixt Stars.
thus ye Moon seems to be in ye same sphere
as ye fixt Stars tho her distt scarce bears any
proportion to ye distt of Saturn much less to ye
immense distt of ye fixed Stars. ye apparent
place of a Celestial objt is determin'd by a Line
drawn fro ye Observers Eye, thro ye body & con
tinued beyond it till it seem to cut ye Sphere
of ye fixt Stars, ye point in wch it cuts ye Sphere
being ye Apparent place of ye Body. — —

the apparent motion is ye Line describ'd among
ye fixed Stars by ye Extremity of ye Line above
Mention'd, we come next now to explain ye Severall
Phænomena arising fro ye motions of ye
planets beginning wth ye Phænomena arising
fro ye Annual & diurnall Motion of ye Earth;
where we shall speak of ye Surface of ye Earth as
particularly. —

10 Let ye Lesser Circle represent ye Earths Annuall
orbit & ye greater ye Sphere of ye fixed Stars.
(Fig 1) Let ye Earth begin to move fro A
to ye B in Consequentia or according to ye
order of Signs: all ye while ye Sun will (by which)
seem to move among ye fixed Stars from
E to D & in one whole revolution will seem
to describe ye great Circle ♎, ♏, ♐ &c
ye apparent way of ye Sun is call'd ye Ecliptick
Line & it is ye Sec. of ye Sphere of fixed Stars
by ye plaine of ye Earths Annual Orb. sup-
-posed to be continued as far as ye Sphere. —

17. This apparent way is divided into 12 p[ar]ts
each containing 30 degrees & distinguish'd by
particul[a]r Names & Charact[e]rs (as sig[n]s)
on either side of y[e] Eclip[ti]c. there is suppos'd to be
a Line drawn parall[e]l to it & dis[tan]t 8° making
a sort of a Zone call'd y[e] Zodiack w[i]th in y[e] bounds
of w[hi]ch y[e] moon & all y[e] planets (by reason of
their small deviatio[n] fro[m] y[e] plane of y[e] Eclip[ti]c)
perform their revolutions. y[e] Longitude of
an Heavenly Body is its dis[tance] fro[m] y[e] first point
of Aries; its Latitude is its dis[tance] fro[m] y[e] Eclip[ti]c.
those Bodies w[hi]ch have y[e] same Longitude
are s[ai]d to be in Conjunctio[n], those, whose
Longitude diff[e]r 180° are in opposition
or at y[e] greatest dis[tance] fro[m] one another. y[e] Axis
of y[e] Eclip[ti]c or Zodiack is a Line drawn thro
y[e] Center,

of ye Sphere of ye fixed Stars perpendicular to ye
Eclipt: ye Extremities of ye line are ~~[illegible]~~
18 call'd ye Poles of ye Eclipt. ye origin of ye Zodiack
wch was. ye Ancient Astronomers observing ye Sun in
its Annual Motion to describe always one & ye
same track in ye Heavens (viz: to pass by
such & such fixt Stars) never deviating from
it either to ye North or South as they found
ye Planets did in some measure & observ
ing him as it were to shift backwds thro all
ye pts of ye Circle or path so as in his whole
years Course he wd rise set & Culminate
wth in every point of it, they distinguish'd
ye fixt Stars wch appear'd in or near
ye Circle into 12 Constellations or
divisions call'd Signs because they were
marks

to distinguish where ye Sun was these for
ye help of their Memory they usually painted
in ye form of Animals, whence came ye
name Zodiack. ye middle of it is called ye
Eclipt. because ye Eclipses only happen
when ye Moon [illegible] is in ye Line as will be shewn
in its proper place. ye other Phenomena
arising from ye motion of ye Earth can't
be well explain'd without giving descriptn
of ye Circles of ye Terraqueous Globe & ye
severall divisions of its surface. — —

19. Astronomers yt they might treat of their
Science ~~[illegible]~~ with great ease imagine cer-
tain Circles to be drawn abt ye Globe;
Such as divide it into equall Hemispheres
or parts they call great Circles, & those
which divide it

Into unequ^l p^{ts} less^r Circles; y^e great^r Circles; are in No^r 6 1^{st} y^e Horrizō, w^{ch} is eithe^r Sensible or Rationall. y^e sensible Horrizō is y^t Circle w^{ch} anyone observes upon y^e Surface of y^e Earth terminating his view every way round him where y^e Heavens & Earth seem to Meet. y^e Ration^l Horizon is a Circle supposd to be parallel to y^e former passing thro y^e Centre of y^e Earth & being continued into y^e Heavens, whose poles are y^e Zenith & Nadir. by y^e Zenith we mean y^t point in y^e Heavens directly over our Heads & y^e Nad^r y^e opposite directly ag^t our feet. 2^{dly} y^e Meridiā, a great Circle whose plane passes thro y^e Centre of y^e Axis & whose poles are y^e East & West points of y^e Horizon. there may be made several meridi-ans upon y^e Globe,

thro ye North & South poles, so as to pass thro any place wtsoevr. But difft nations are not agreed where to fix ye great meridian of all: some drawing it thro Graliosa one of ye Azores Islands, others (as ye French) thro ~~[illegible]~~ Fero one of ye Canaries.
3dly ye Equator, wch divides ye Globe into 2 Hemispheres North & south; its Poles, Consequently are ye Poles of ye world.
4thly & 5thly, ye Colours wch are 2 great Circles passing thro ye Poles of ye world & cutting ye Equatr at right Angles into 4 equall pts, one of em passing thro ye Equinoc-tial points Aries & Libra called ye Equinoctial Colour, ye other thro ye

Solsticiall points Cancer & Capricorn
called ye Solsticiall Colours. 6thly ye Zodiack
as above described. ——

20 The 4 Lesser Circles are first ye 2 tropicks
of cancer & capricorn drawn on Each
side ye Equator parallel to it & at ye dist.
23°: 30'. The tropick of Cancer lyes
North & yt of Capricorn lo ye South
side of ye Line. 2dly ye polar Circles wch are
also supposed to be drawn parallel
to ye Equator & round Each Pole at ye
dist. of 23°: 30' from it: yt round ye
North pole being called ye Artick
Circle & yt about ye South pole ye
Antarctick. ——

21 The Lesser Circles were suppos'd by ye
Ancients to divide ye Earth into 5
Zones. ye Spaces contain'd between ye
tropicks & polar Circle Each side of
ye æquator they Called ye North &
South Temperate Zones, ye Spaces
Contain'd within ye Polar Circles
they were Term'd ye North & South
frigid Zones, ye Space contain'd
between ye tropicks & wch is bisected
by ye Equator they call'd ye Torrid Zone.
thus much was Necessary to be premis'd
to ye better understanding ye Phænomena
Arising from ye motion of ye Earth.—
22 At ye Real Annual revolution of ye Earth

Causes an Apparent Annuall Revolutio of ye Sun, so ye diurnall Rotation of ye Earth causes by ye same principles an apparent Diurnall motion of ye Sun. for wn by ye Rotation of ye Earth from west to East round it's Axeis (perform'd in ye space of 24 hours) ye western Horizon is so much elevated & ye Eastern depress'd yt it appears below ye Sun, we yt stand upon ye Surface of ye Earth & are together wth our atmosphere evenly moved along wth it, are apt to think yt ye Sun actually rises above ye Horizon & not yt ye Horizon falls below ye Sun

23: Hence ye Sphere of ye fixt stars seems to revolve in ye space of 24 hours

66°, 30

round ye Earth, describing great Circles ye 289
more dist they are fro ye poles; hence arise
ye Vicissitudes of day & Night, for ye Earth
being a Sphericall Opake body, while
one pt is turn'd to ye Sun ye other must
be involv'd in darkness. — ——
24 Did ye plane of ye Equator coincide wth ye
plaine of ye Eclipt. ye Axis of ye Earth
wd stand perpendicular to it. ye bounding
Circle of Light & darkness wd conse-
quently pass thro ye 2 poles of ye Earth thereby
making Day & Night always eqll & a
perpetual spring. But ye Axes of ye Earth
is inclin'd to ye plane of ye Ecliptick thereby
making an Angle of 66:31 therefore
ye plane of ye Equatr is inclin'd to ye
plane,

Of ye Eclip! In an Angle of 23°: 30' those planes intersecting one another in ye 1st point of Aries & Libra. ye Axis of ye Earth being thus inclin'd to ye plane of ye Eclip! & moving parallel to its self in all pts of its Annuall orb.t is ye Occasion of ye inequality of Day & Night & of ye diff! Seasons of ye year wch are ye 2 Phenomena we come next to explain having first premised ye following Lemma for proving ye parallelism of ye Earth's Axis

P. 1 Lemma 1st If a Line moves parallel to its self & receives an Impulse in ye same direct to it wch Continues to prove parallel to its self but fast again suppose ye Impulse

not in ye same direction, still it will keep on ye same parallelism (Fig. 2) suppose ye Line do moving on in ye line dc to reive an Impulse at b downwards; the ye direct. be changed ye Parallelism will still remain. for ye Extremity d has as much Velocity as b & Consequently d must move to f with in ye same time yt b arives at e & g which are lines parallel to ye former. ——

20. Lemma 2d If a sphere moves uniformly in it's direction without a motion about any of its Diamrs, as about its Axis, then every one of these Diamtrs will move parallel to its self. Suppose A B (Fig. 3d) ye Extremities of a Diamr of a Sphere moving eqully in ye pricked Lines A b B & to come to ye line a, b.

in ye same time; they wd yn have kept ye same parallelism: for ye prickt Lines a A b B are describd by ye 2 extremeties wth ye same velocity & in ye same time, therefore ye whole Diamtr must bring ye positiō A B wch is parallel to a b. —

27. Lemma 3d. If a Sphere moving wth ye Conditions abovementiond receives an Impulse perpen-dicular to its Surface it shd not bring ye powr of ye Impulse to Change ye parallelism of any one of its diamtrs but only its directio,

ex. gr. Suppose a Globe moves wth its axis parallel to its self in direction towds E (fig 4) but receives a pull from ye Sun at S wch is ye Same ~~as~~ as an Impulse given it perpendicularly at S, ye pull or attraction of ye Sun hindrs it fro going to E but brings its direction,

[illegible], but yet it w^d keep its parallelism all y^e way round, by Lemma y^e 2^d. now instead of supposing em' pull at every Corner let us suppose these pulls to be every Moment & y^n y^e Bodies w^d describe a Curve but no Alteration w^d be made in y^e Parallelism of its Axis.

28 Hence If a Body suppose a Planet moves ab^t y^e Sun & at y^e same time ab^t its Axis, y^t Axis shall nevertheless move in a position parallel to its self. for it has been shewn from y^e foregoing Lemmats, y^t if a Body moves ab^t y^e Sun, its Diameters w^d always be parallel; now let us suppose y^e Body to move ab^t one of its Diameters as ab^t an axis, all y^e other diam^rs w^d change their parallelism but y^t because it is at rest. for did y^e Axis move round it must have an axis to move ab^t. so y^t at last there w^d be found an axis y^t doth not move

& Consequently it keeps its self parallel to its

&c. — — — — — — —

29 Having Evinced y^e parallelism of y^e Earths Axis we come next to show how from y^t Parallelism & y^e Inclination of y^e Axis of y^e Earth to y^e plane of y^e Eclip^t, y^e Inequality of Days & Nights & y^e Diff^t seasons of y^e year may be explained, we must only observe y^t y^e Sun w^d appear Verti-cal to y^t p^t of y^e Surface of y^e Earth, w^{ch} is Cut by a Line drawn fro y^e Centre of y^e Earth to y^e Centre of y^e Sun. Now w^n y^e Earth is at ♑ see fig. 28. B.1. of Geog. Astron. y^e Sun w^d appear vertical to y^e Nothern Tropick, AC, for y^e Line S,♑ Cuts y^e Surface of y^e Earth in it; therefore those who live in y^e Northern Hemisphere EBZ w^d enjoy Summer y^e Rays of y^e Sun falling most perpendicularly upon their Hemisphere,

at yt time. at ye same time ye Inhabitants of ye Hemisphere EAQ wd have ye Rays of ye Sun falling more obliquely upon ym & affording ym less Heat. Again ye Inhabitants of ye Northern Hemisphere wd have their days Long & ye ~~their~~ Nights in proportion as they are dist. from ye Equat. those who live und. ye Equat. have all ye year round an equal share of light & darkness. for it appears ~~from ye bare~~ sight of ye fig yt but half of ye Equat. is enlightned more yn half T C (ye tropick of Cancer) & all K Z (ye Polar Circle) now suppose ye Earth to make one revolution round its Axis B A & ye Quantity of those Circles wd remain illuminated, as before, wn we Consid. ye Earth as standing still hence it Necessarily follows, yt those who live Und. EQ wd have their days & Nights eql.

Those who live between E2 & H (viz: the
Inhabitants of ye Northern temperate Zone
& ye Northern pt of ye torrid Zone) wh have their
Nights short & their Days, whilst ye pts
within ye polar Circle KL enjoy perpetual
Day ye Sun being ever above their Horizon
in ye mean time ye Inhabitants of ye Southern
Hemisphere wh have their Nights long & ye
their days proportionably as they approach
Nearer ye Southern Pole A: & those contained
within ye polar Circle LG wh have a perpetual
Night All wch is plain from ye sight of ye fig:
30: At ye time during ye time yt ye Earth is
really in ♑ ye Sun wh appears to be in ye
opposite point ♋: wherefore ye Circle wch ye
Sun seems to pass over wh he is in his greatest
Northern declination from ye Equator is call'd
ye tropick of Cancer. Let us now suppose ye
Earth to move in its orbit

fro ♑ through ♒ & ♓ to ♈ & ye Sun wd
Appear to have run through ♌, ♍ entring
into ♎ & yt wd be ye Suns place in Autumn.

31 Whilst ye Earth is in ♈ ye days & nights wd
be eqll in both Hemispheres & ye Seasons
in a medium between Sumr & Wintr. for wn ye
Earth is at ♈ ye Sun wd appear in ye ♎ & ye
Equatr EQ because a right Line drawn
fro S to ♈ wd cut of ye Surface of ye Earth
in some point of EQ, for in position of ye
Earth ye Line S ♈ must be supposd per-
pendicular to ye Axis B A, (though it
cannot be clearly represented in plano)
so yt ye Circle bounding ye Light & Dark
-ness wd pass thro ye poles; & Consequently
at yt time of ye year all ye pts of ye Earth wd
have an eqll share of Day & Night. & because
ye Rays of ye Sun shd perpendicularly to ye Axis
of ye Earth

it follows y^t. they must fall w^th in y^e obliquity on either Hemisphere, therefore they must enjoy an Equ^l. degree of Heat & Cold. –

32. Let us now suppose y^e Earth to move fro ♈ to ♋ & y^e Sun w^th. same to move fro ♎ to ♑ where w^d be its greatest declinatio, & consequently at y^t time of y^e Year it w^d be our wint^r for here y^e like Phænomena w^d happen to y^e Northern Hemisphere as happen'd before to y^e Southern, w^n y^e Earth is in ♑ ♋ & vice versa: & y^e party of reason y^e Nothern Hemisphere w^d enjoy wint^r, y^e South^n. Sumer:

33. The 4 points of y^e Eclip^t. in w^ch y^e Sun is plac'd in our present fig are call'd y^e 4 Cardin^l. points; viz: y^e 2 Solsticial, & y^e 2 equinoctial points. y^e 1^st point of ♋ is call'd y^e Sumer Solsticial point; for w^n y^e Sun enters it as he doth ab^t y^e 11^th. June being at his greatest Nothern declinatio before he turns back

he seems for a day or 2 to stand. ye first point of ♑ is called ye wintr Solsticiall point wth respect to our Hemisphere wn ye Sun enters ye Decemr. ye 1st points of ♈ & ♎ are called Autumnall Equinoctiall points; from ye Equality of day & night over all ye Earth wn ye Sun is in either of those points: though we have here consid'd ye Earth only as situa'd in ye 4 Cardinall points, yet it wd be easie to apply wt has been sd to any immediate point of ye Ecliptick: so much for ye Phænomena arising from ye Diurnall & Annuall motion of ye Earth: we come now to explain ye rest of ye usuall terms abt ye Globes.—

34: Besides ye Circles mention'd in Sect. 19 & 20 there are ye Azimuths or verticall Circles wch meeting ye Zenith & Nadir, as ye meridians in ye poles, they cut ye Horizon at right angles & on ym is reckon'd ye Suns Altitude wn he is not in ye Meridian.—

2dly Alimacantaracks or parallels of Latitude
wch are circles parallel to ye Horizon & conseq-
-uently have 3 poles in ye Zenith & Nadir;
Those diminish gradually ye further they go
fro ye Horizon. 3dly parallels of ye declinatiō
of ye Sun & Stars wch are Circles parallel to ye
Equator Either North or South; their poles
therefore are ye poles of ye World, & on ye ter-
restrial Globe they are called parallels
of Latitude. — — — — —

35 By ye Latitude of a place is meant its dist.
fro ye Equator: & because yt is always equal
to ye Elevation of ye pole above ye Horizō
tis often expressd by ye poles height or eleva-
tion of ye pole ~~above ye Horizon~~ ye Long-
itude of a place is its dist. East or west fro ye
first meridiā reckoned always along ye
Equator. ye Amplitude of ye Sun or of a Star
is an Arch of ye Horizon intercepted be-
twixt its true East & west points where ye
Sun or Star ~~r~~ raises or sets. — — —

36: The Inhabitants of ye Earth according to their Diffnt Situation on its Surface are sd to Inhabit a right, parallel or oblique Sphere. 1st those who live directly under ye Equator inhabit a Right Sphere; for they having ye Equator in ye Zenith & ye Poles in ye Horizon all ye Stars once in 24 hours rise, culminate & set at ye m & ye Sun always rises & sets at right Angles with ye Horizon: 2dly those who live directly under ye North & South poles live in a parallel Sphere, having every ye Poles in their Zenith & Nadir & ye Equator in their Horizon: therefore they can only see such Stars as are on their side ye Equinoctial, they must also have 6 Weeks continued Night & ye Sun cannot be higher with ym yn 23d: 30m.
about his height with us at 6d 1/2.

[illegible]

they have howev^r some Elevations to temp^r those extreams. for there is seen in their Atmosphere once in 24 or oftner as Meteor call'd Aurora Borealis (sometimes seen even in our Latitude) w^ch affords y^m a great deal of Light, their Atmosphere also being dens^r y^n ours their twilight must be much bright^r y^n ours; but of y^s more w^n we come to speak of y^e Crepusculi. 3^dly an oblique Sphere is w^n y^e pole is elevated above y^e Horizon any No^r of Degrees less y^n 90. Here y^e Axis of y^e Earth being oblique to y^e Horizon y^e Equat^r & parallels of declinatiō w^ch cut it at R^t Angles are oblique to y^e Hor^n &c.

37\. The right ascensiō of y^e Sun or of a Star in a right Sphere is y^t degree of y^e Equinoctial, (reckon'd from y^e first point of Aries) w^ch rises & sets w^th y^e Sun or Star:

In an obliqe Sphere it is ye degree of Equinoctial
wch rises or sets wth ye Star in an Obliqe Sphere.
ye Ascensionall Diffr is ye diffr between ye right
& obliqe ascension wn ye lesser is Substracted
from ye greatr. a Star is sd to set & rise Cosmically
when it rises & sets wth ye Sun. Achronically
when it rises, when ye Sun sets, A Star is sd to rise
Heliacally when it appears in ye morning
a little before ye Sun being just in ye extremity
of its Light, & when ye Sun comes so near it as to
out shine it & make it disappear before it
has got below ye Horizon.

38 The Surface of ye Earth is divided into Climates
& parallels. ye Climates begin at ye Equator
& are reckoned 24 to ye North & as many
to ye South: when ye are got so far fro ye Equator
yt ye day is become ½ an hour longer or shorter.

yt und.r ye Equat.r, yey are s.d to come into ye first Climate, & it varies an hour ye are come into ye 2d Climate. 2dly. A parallel is ½ of a Climate & therefore is determined by ¼ of an Hour's Variation in ye Length of a Day.

39: The Inhabitants of ye Earth wth respect to ye falling of their Shadows are either Amphiscii Heteroscii or Periscii 1st. ye Amphiscii, who inhabit ye torrid Zone have their Shadows cast tow.d South wn wn ye Sun is in ye Northern Signs & tow.d Northw.d wn he is in ye Southern Signs. They have ye Sun twice a year in their Zenith, & at yt time are Ascii i.e having no Shadows ye Sun yn being vertical. 2dly. Heteroscii, whose Shadows fall but one way all ye Year, these are ye Inhabitants of ye 2 temperate Zones. those who live in ye North temperate Zone have their Shadows at Noon always to ye North & those yt live in ye Southern tow.d South. 3dly. Periscii, who live wthin ye polar Circles & therefore have their Shadows falling all manner of ways; ——

20

because ye Sun as long as he is in ye Horizon goes clear round abt em. — — — —

10. The Inhabit. of ye Earth wth respect to one another either ye perioeci, Antoeci, or Antipodes, 1st ye perioeci, who inhabit. ye same parallel but directly opposite to one another, ye one being west ye other East Exactly 180 or half a Circle. these being on ye same side of ye Equatr & having ye same Latitude have Sumr & Wintr alike; but wn tis Noon wth one tis midnight wth ye other. 2dly ye Antoeci are those who live undr a semicircle of ye same meridian at eql dist. from ye Equatr: one to ye South ye other to ye North; these having ye seasons of ye year directly contrary but day & night at ye same time. 3dly ye Antipodes are those who are Diametrically Oposite to Each other;

ye Zenith of one being ye Nadir of ye other, so they wch ~~feet to feet~~ & are dist. fro one another an Entire Diamr. of ye Earth. Therefore they have all things as well Day & Night as wintr. & Summer directly contrary.
41 We shl. conclude ys Chapt. wth observing yt besides ye inequalities of days & Nights & of diffl. seasons of ye year there is yet another inequality. I mean ye wintr. half years being 8 days shortr. yn ye Summers. wch is easily solvd. by ye motio of ye Earth; for since ye Earth revolves in an Elliptical orbt. it must move faster in perihelio yn in Aphelio otherwise it cd. not describe eql. Areas in eql. times. & since ye wintr. Solstitial point Coincides wth ye perihelium, it follows,

yt ye Earth must pass thro ye wintr Signs swifter yn thro ye Summers signs. —

42\. Here ꝑhaps it may be ask'd why ye weather should be coldest in wintr wn we are nearest of all to ye Sun & consequently ought to enjoy most of his Heat. It may be answd yt ye Eccentricity of ye Earth is so smal & consequently ye diffe of dist in Wintr & Sumr so very inconsidle wth respt to ye immense dist of ye Sun yt there can be no sensible diffr in ye Heat upon yt acct. but ye true reason is yt in Sumr ye Rays fall more ꝑpendicular upon our Northern Hemisphere yn they do upon ye Southern & more copiously; & it appears fro Mechanicks yt a ray falling ꝑpendiculy (as S.T. Fig.)

Causes much more Heat yn ye falls obliquely.

43. It may be obj.d again yt if ye want of heat were owing to ye perpendicularity of ye Suns Rays we might easily remedy ye Cold in Wint.r by lying upon ye Side of a hill, & making ye Sun rays fall perpendicularly upon us. yt posture wd indeed do good in some Measure but not entirely, by reason of ye Cold Chilling disposition of ye Air & all things abt at yt time of ye year. having Now Explaind wt Necessary concerning ye Phænomena Arising fro ye Anual & diurnal motion of ye Earth we come now to ye Phænomena of ye other planets, arising fro ye Earth & their own Motions in their orbits beginning wth ye inferiour planets.—

The Phænomena of ye Inferiour planets Explaind.—

44. Let A B C represent a portion of ye Sphere of ye fixt Stars.—

(Fig. 6) E O P ye Earths orbit; L M Q ye orbit
of an inferior planet Venus & S ye Sun.
Let us first suppose ye Earth to stand still
in its orbit at E; here tis plain fro ye sight of ye
Eye of ye Sun wd appear at ye point B & ye Planet
always within ye Ark A C; while ye planet moves
round fro Q to M she wd seem to move fro B to
A according to ye ord of ye Signs. But passing
fro M to L she wd seem to a Spectator at E
to return back fro A to B ys is Call'd ye retrograde
Motio being apparently contrary to ye ord of
of Signs; whilst she is at or near ye point M
being betwixt moving on fro B to A & return
ing fro A to B & seeming to move in a right
line to ye Earth she wd appear to stand
still.

(as to ye progressive or regressive motion)
& yt is to be Stationary.—

45. When she is in ye pt of her Orbit where by ye Earth is contiguous to Ea or E C she wd yt appear at her greatest dist fro ye Sun at wch time is to be in her greatest Elongation. ye Elongation is measured by ye Angle S E G. ye more dist any planet is from ye Sun ye great is its Angle of Elongation, whence ye greatest Elongn of Venus subtends an Angle of 48° & yt of Mercury but 28°.

46 Hence it appears yt an inferiour planet can never come to ye Quartile of ye Sun (for yn ye Angle S E G wd be a right one) much less to an Opposition wth him.

But in ye Space of one revolution it mustund=
=go 2 Conjunctions one wn it is beyond ye Sun
at S ye other wn it is betwixt ye Sun & ye
Earth at L: ye former is Called ye Superiour
ye latt. ye inferiour Conjunction. whilst
Venus moves fro ye Superior to ye infer con
junt. She appears in ye Arch L S & always to
ye Eastwd. of ye Sun; therefore all ye while she
Sets after ye Sun is called ye hesperous or
Even: Star whilst she goes on fro ye inferior
to ye Superior Conjunctio She will be seen
somewhere in ye Arch S L west.n of ye Sun
& will yn set before him in ye Evening & rise
before him in ye morning & is yn Called
ye phosporos or morning Star——

44. We have hitherto only supposed ye planet to move while ye Earth stands still. if we suppose both ye Earth & ye planet to move ye foregoing Phænomena wd be much ye same, only ye planet wd be more ye ordinarily direct in ye farthest pt of its orbt. ye motio of ye Earth contributing thereto as well as its own motio. & less ye ordinary its retrogade ye motio of ye Earth being a means to lessen her retrogradations the former being ye Sum ye latr ye diffce of their motions.

48 Since ye planes of ye planetary orbts are variously Inclined to ye place of ye Eclipt they wll have seemingly diffl Latitudes or be at diffl dist. fro ye Eclipt accordng as they are viewd fro ~~ye~~ diffl places.

The Latitude of a planet wn viewd fro ye Centre of ye Earth is called ye Geocentrick Latitude wn viewd fromye of ye Sun ill Helocentrick Lat. ye Heleocentrk Lat. wd be continually encreasing as ye plan. recedes fro ye Nodes where it has no Lat. at all; therefore ye plat. wd be greatest of all. wn ye plan. is in ye point of its orb. wch is equidist. fro ye Nodes. yt point therefore is calld ye Limits or utmost Limit of it: ye Geocentrick Lat. may vary tho ye Heliocentrick remains ye same for since ye Geocentrick aswell as ye Helio centrick is determd by a Line drawn perpen-dicul. to ye Eclip. so as to connect ye plane of ye planets orb. to ye plane of ye Eclip. ye Angle under wch ye Line is ~~[illegible]~~ seen by a Spectatr upon ye Earth must vary according to ye dist. of ye Earth fro ye planet.

49. The long[?] faces of ye inferior plan.ts & their diff.t apparent magnitudes with ye Moon having a better opportunity of explaining them after having given Acct of those of ye Moon, therefore it remains only here to observe yt wt has been said in sect 45 admits of some except.n upon acct of ye Ecliptical orb.t of ye planets, but they differ so little fro perfect circles yt it may be neglected witht any sensible ~~______~~ error. — — —

Of ye Phaenomena of ye Superiour planets.

50. The direct stationary & retrograde motions of ye Super. Plan.ts & most of ye other Phaenomena are explained much after ye same manner as those of ye Inferior, but with these differences. 1st ye retrogradations of ye Sup. planets happen ofter ye slower their Angular motions are: as ye retrograd.ns of ye infer. Plan.ts happen oftner ye swifter their Angular motions are.

Because yᵉ Retrogradations of yᵉ form depend upon yᵉ Angul. motions of yᵉ Earth but those of yᵉ latter upon their own Angul. motion. A superior plan.ᵗ is retrograde once in each revolution of yᵉ Earth; an inferior once in every revolution of its own. N B. by an Angul. Motion is meant yᵉ increase of yᵉ dist. betwen any 2 plan.ᵗˢ revolving round yᵉ Sun & is Expressed by right Lines drawn from yᵉ Centre of yᵉ Sun to yᵉ Centre of yᵉ revolving planets, wᶜʰ open wider & wider as yᵉ plan.ᵗˢ pass further & further fro one another. 2ᵈˡʸ yᵉ Superior plan.ᵗˢ do not always accompany yᵉ Sun as yᵉ inferior do but are often in opposition wᶜʰ necessarily fol from yᵉ orbis magnus or orb. of yᵉ Earth being included wᵗʰin yᵉ orb.ᵗˢ of yᵉ Superior plan.ᵗˢ we come now to explain yᵉ Phænomena of yᵉ secondary plan.ᵗˢ & first those of yᵉ Moon.

54. The Moon Continually revolves fro East to West round ye Earth in an Ellipl orbt
+ carried thro ye Orbis magnus together wth ye Earth making 13 periodicall & 12 Synodicall months in revolving round ye Earth
- while it makes but one revolutn round ye Sun. by a periodical month is meant ye time ye moon takes up in passing fro any one point Of her orbt to ye same agn consisting of 27 Days, 7 hours. 43. But a synodical month is ye time she spends in passing fro one Conjn to another; wh is 29 - 12h: 44 being 2d: 5h: 1 longr ythn ye periodl Month. for whilst ye Moon is passing fro her formr Conjunc! wth ye Sun round to it again ye Earth has proceeded forwd something in her Annl Course & as if were left ye Moon behind her so yt in ordr to Compleat her next Conjunc! wth ye Sun she must not only come round agn to her formr point but also go a smal dist! beyond it.

N^o2. Beside y^e Monstru^ll motion of y^e Moon round y^e Earth She has also a motion round her axis w^ch is perform^d exactly in y^e same time period-dic^ll revol^n fro whence it comes to pass y^t y^e same Phase of y^e Moon is always turn^d to-w^ds us, Her diurn^l motion turning just as much of her Phase tow^s as y^e periodic^l turns fro us. tho y^e Moon be really of an orb^l fig: yet her face seems flat by reason of her vast dis^t.

N^o3: Tho y^e same side of y^e Moon be ever turned tow^ds us yet it is not always wholly visible but daily puts on diff^t [illegible]faces. for y^e Moon being an Opake Body like y^e rest of y^e planets borrows all its light fro y^e Sun having 1 Hemisph^e enlightned w^th y^e Sol^r Rays. w^n y^e enlightned Hemisphere is wholly turned fro y^e Earth.—

as in ye moon, ye plant being yn betwixt us &
ye Sun her whole disk must needs be invisible to us.
It must also appear horned, wn Emerging
fro this state it turns some smal portio of ye
Illuminated half to us; wn it is removed
almost 90° fro ye Sun it must appear bis
sected: after yt wn it shews us more yn ½ of ye
Enlightned Hemisphere; it wd seem Gib
-bous till at length ye Earth being well nigh
got betwixt ye Sun & moon her whole Illuminated
orb must be presented to us. fro whence receding
she must put on ye like Phases as before but in an
inverted ordr & wth ye horns turned a diff: way.
all wch may be Confirmed by a very small Experimt
for if you take a Ball or Globe & paint ½ of it
black & ye other ½ white & yn move it round ye
eye it will present you wth ye same appearances

Succesively, as ye Moon exhibits in ye Heavens;
this leads us to a Solution of ye Phænm.
54: When she is at her infer.r conjunctio at L her
Illuminated orb being turned from us she wd
be wholly invisible to us at E; when she has
Fig: got near M some pt of her Luminous orb wd
be turned towds us, but much more of ye dark.
therefore she wd appear horned wth her horns
turned towd West, or from ye Sun; she wd appear
bisected between M & Q: gibbous at R & full
at S ye Superior Conjunction. As she goes for-
-wd she wd put on ye very same phases suc-
-cessively but in an inverse order turning her
horns towd East or towds ye Sun. while she
is in ye morning Star her horns wd be turned
from ye Sun & when ye Evening Star towd him.
55: Here it may be asked why Venus does not
appear Brightest when she is

abt. 9. (Since ye Moon yt Shines wth a full orb) yt she doth abt Mer. & where she is corniculate tis answd wn she is at or near her superior Con junction, her great dist. diminishes her appart. Magnitude. but wn she is abt. Mer. & she see be only Corniculated yet ys is abundantly Compensated by her approaching neare tous; for since her splendr increases as ye squares of her dist. decrease; it is in ye Case much more encreased by her nearness yn tis decreased in respects of ye small Quantity of ye Enlightned Hemisphere wch is turnd tows. us.——

56: Those who have made use of ye best Glasses have discovered ye same Phases & diff. magnitudes in Mercury as are observable in venus. ye Superior plants both in opposition & conjun tion turnd their Enlightned Hemispheres tous: so yt since ye 2 extreames of full & obscure are not found here as in ye Infer. plants Conse quently these put on none of ye intermediate Phases, as Corniculate, half full & gibbous. only Mars by reason of his nearness to ye Earth appears sometime a little gibbous but to return to ye Moon.——

57: The plane of ye Moons orbt is variously inclind to ye plane of ye Eclipt.; but ye variation seldo Exceeds 5°: 18'. ye Nodes of her Orbt are denoted by these Charactrs ☊, ☋; ye former is called ye Dragon's head where she entrs into ye pt of her orb wch declines Northwd fro ye Eclipt.: ye Latter is termd ye Dragons tail, wch she crosses wn she entrs into her Southern declination. ye formr is called ☊ [illegible] ye ascending Node, ye Latter ☋ ye decending Node. — —

Of ye Lunar Inequalities.

58 We shall reduce ye Lunr inequalities into 3 heads; und ye first we shall Consider those wch relate to ye situatio of her orb; und ye 2d those wch respect ye fig of it, und ye 3d ye in-

59 equalities of her velocity wth respt to ye situatio, it is observd by ye Lunar Tables ye inc-lin does not always bear ye same proportion in all ye points of ye orbis magnus but is continually moving

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In consequentia, for tho' it goes forw^d in y^e new & full, & backw^d in y^e Quadratures yet it's motion in consequentia is as swift again as its motion in Antecedentia. therefore upon y^e whole y^e Excess must be upon y^e progressive side & y^e Apsides must advance according to y^e ord^r of y^e Signs. for they are observed to move 3 degrees every revolution of y^e moon so y^t they revolve thro' y^e Eclip^t in y^e space of 9 years.

60 There is also 2^dly an Inequality in y^e Inclinatio of y^e Lun^r orb^t to y^e plane of y^e Eclip^t arising fro' y^e Change of y^e Nodes w^n y^e line of y^e Nodes is placed in y^e Syzygies y^e Nodes are at rest: but w^n in y^e Quadratures they go most swiftly backw^d & in y^e intermediate places

are carried wth a mean Velocity in antece-
dentia making one revolutio round ye
Eclipt. in ye space of 19 years. when ye Nodes
are at rest in ye syzygies, ye Angle of In
clinatio is greatest of all & least in
ye quadratures where they are swiftest
but twill be easier to conceive ye Phe
nomenon if we suppose ye Moons men
menstrual motio to be performed in a plane
wch hath ye Body of ye Moon fixt in
it & yt ye plane be Imagin'd to be carr
ied by some extrinsick force & so propp
p turns abt the line of ye Nodes as an
Axes; in ye meantime whilst ye Moon
performs her Circuit yt yt be done in such a
Mann: yt it be most elevated wn ye Line of
Nodes falls in ye new & full: ----

Most depress'd w^n y^e Quadratures, & more or less elevated in y^e proportio of y^e dist. of y^e Line of Nodes from y^e Syzygies & thus may y^e Moons true Latitude be conceived at any time tho it be in it's self ever changing & varying – — —

61 Both these Irregularities are owing to y^e Disturbing force of y^e Sun: first in ord^r to und^rstand how y^e Motion of y^e Moons apsides is Caused by y^e Action of y^e Sun, thus Imagine a Bullet Shot out of a musq^t inclined in a certain degrees Angles to y^e Horizon: y^e Bullet w^ll according to y^e Laws of Mechanicks in its Ascent & descent describe a Parabola y^e highest point of w^ch may be call'd its Vertex or Apsis. Let y^e same Bullet be sent out again fro y^e musq^t in y^e same directio but w^th a much great^r Velocity. it w^ll now move high^r & fast^r before it Comes to it's vertex or Apsis. its apsis speaking Astronomically, may be s^d now to move forw^d. —

To Apply this. Suppose ye Moons Apogee
or ye point of its orbit most dist. from ye Earth
turn'd to ye Sun: as she comes from her
Quadratures till she is continually
Accelerated in her Motion (as we shall
see below) by wch means it comes to pass
yt her Apsis moves forwd just as ye Bullet
Apsis mov'd forwds wn it was sent out of ye magnet
wth a great Velocity; as also if ye Sun wd
Annihilate ye Moons next Apsis wd be Di-
rectly opposite to ys (for wn one Apsis moves
both must, they being ye 2 extremities of ye
same line) but because ye Sun Accelerates
ye Moon from her next Quadrature to her
next Apsis, ye Apsis will always be forced forwd
& wn one is forced forwd it must as has
been observ'd carry ye other along wth it.

The Apsides of the Primary planets move so very little that their motion is called Lentissimus apsidum motus & it is entirely owing to the Actions of the Primary planets upon one another & not at all to the Sun, to which is owing the motion of the Moons Aspides. for Sir Isaac Newton has demonstrated that if the Sun lies in the plain & centre of any planets orbit as he doth exactly in the planes & Centres of all the orbits of the primary planets that that planet would describe an Immoveable Ellipsis so that whatever point of the Heavens the Earths Aspides point 1 year, they would physically speaking point to the same the next. but it is otherwise with the secondary planets which have not the Sun in the planes & Centre of their Orbits....

62. The Action of the Sun gives motion to the moons body =

by pulling her out of ye plane of her orb. because (as had been sd. before) he doth not lie in ye plane of it. in ye same manner & for ye same reason, he affts. ye Nodes of ye other Secondaries; as for ye Nodes of ye primary planets he affts. ym not at all because he is in ye plane of their orbs. — — —

63. We come next to ye Variations in ye fig. of ye Moons orb. tis observed yt ye excentricity of it varies Continually approaching more or less to ~~a~~ Circular fig: according to its difft. situations wth respt. to ye Sun for wn ye line of ye Apsides is in Syzygie ye ~~Exc~~ Excentricity is ye greatest, & least in ye Quadratures; & gradually or less made propotionally in all ye intermediate spaces: ye variation is allso owing to ye Actions of ye Sun;

for suppose y^e Moon's Orb w^{ch} very Excentric is y^e Earth. This might seem y^e contrary & make a right Line & suppose y^e Apsides in y^e Syzygies y^e Orb of y^e Moon w^d be always in y^e Syzygies. in y^e Contrary if y^e suppose them in y^e Quadratures y^e Apsis w^d always be in y^e Quadratures & [illegible] never in y^e Syzygies & as its Orb is more or less Excentric y^e Diam^r of y^e Moon (for its apogee is [illegible] y^e sun [illegible] having y^e more force to alter its) is found [illegible] her in some measure out of her orb, w^{ch} makes her orb more Excentric y^n y^e time y^t its Apsides were in y^e Quadratures. this means y^t gravity is most powerfull w^n it Acts in Right Lines, but Acts straight Lines w^n y^e Moons Apsides are in y^e Syzygies & in Oblique ones w^n in y^e Quadratures: —

Excentricity of ye Moon's orbit [illegible] is
(as drawn out of here[illegible]) wch shews it greater in ye
Syzygies yn wn in ye quadratures.

7. Wee come next to ye inequalities of the
Moons motion, wch by reason of ye greatness
of their irregularity & having little or no
dependance on one another canot be brought
under any General Rules. For 1st by ye Earths
attraction her motion in general is swifter
yn in Aphelio (as wee said above, [illegible]
15. 10.) 2. by reason of ye [illegible] of her orb
she must move slower in her Apogee & swifter
in her Perigeum, yt she may describe equall
Areas in equall times. 3. ye velocity of ye Perigee
& Apogee vary upon ye acct of ye variation
excentricity of ye Sun's orbit. 4. ye Moons
[illegible] mean motion wth respect to her various distance
from ye Apogee [illegible] Quadratures is [illegible]
[illegible] in Conjunction than in Quadrature.

she is continually retarded; accelerated in ye
2d Qr; retarded again in ye 3d & accelerated again
in ye last. This inequality of ye Moon's motion
(first observed by Tycho Brahe & by him called ye
variation of ye Moon) has by Sr Isaac Newton
been explained in his Theory of universal
gravitation & like ye Inequalities of all ye other
Secondary planets proceeds wise from ye same
Cause; for in ye motion of ye Moon from ye Conjunct.
of ye first Quadrature ye Action of ye Sun continu[ally]
increases ye gravity of ye Moon to ye Earth
& Consequently (by Mechan: 115) retards ye
Motion: But in ye motion from ye Quadrature
to ye opposition every moment ye moon's
gravity is diminished & thereby ye motion
in its orbit is accelerated; by ye same
means in its motion retarded in ye 3d
& accelerated again in ye last Quar. We
shall conclude our Theory of ye moon with
The Libration of ye moon. Vide Sect 65 [See ye variation of ye moon explained above. Mech. Sect. 115. 116]

J Consequentie

Something farther Concerning ye motion of ye Apsides

wch is ye Force disturbing ye Moon [illegible] in 2 ways, 1st wth regard to ye position of ye Moon in her orb. 2d wth regard to ye position of ye Apsides of ye Orbit. It [illegible] has been shewn by Sr Isaac Newton (49: cor. 1) yt if ye attractive force Continued always reciprocally proportionl to ye Squares of ye dist. ye Apsides wd not move at all. if it varys in a greater proportion yn ye reciprocl duplicate they wd move in consequentia, if in a less proportion yn in antecedentia. But it has been also demonstrated yt ye force varys in a greater yn yt proportion in ye Syzygies, in a less in ye Quadratures; therefore in ye Syzygies ye Apsides wd move in Consequentia in ye Quad: in antecedentia But tis demonstrated yt ye variation in ye Syzygies is to yt in ye Quadratures as 2 to 1; therefore ye Motion in consequentia is [illegible] double

y^e motion in antecedentia & Consequently 382
on y^e whole they w^d have a progressive
Motion by y^e Exc: of y^r retrograde motion they
had in antecedentia in y^e Quadratures.
2^ly As y^e progression or regression of y^e Apsides
depends on y^e variation of y^e Dis^t Centripetal
being greater or less y^n in a recipro^l
Duplicate Ratio of y^e Dis^t & as y^t varia
tion w^d take place more or less as y^e Dis^t
is greater or less, it follows y^t y^e progression
of y^e Apsides must be greatest w^n they are
placed in y^e Syzygies & their regression
greatest w^n they lie in y^e Quadrat^s. y^e ine
quality proceeding from y^e last Cause the
weak^r is more Considerable y^n y^t proceed
ing from y^e former the strong^r y^n because
y^e time in w^ch y^e latter acts is much greater
y^n y^e time in w^ch y^e former Acts, for as y^e
Moon performs her revolution in a Month

She can Continue in one Syzygy only a
Week but ye motion of ye Apsides is such (ye
same apsis is turn'd tow(ards) ye Sun (or conti-
-nues in ye Syzygy) 100 days; for were ye
Apsides to stand still ye Sun wd move fro
Apsis summa to Ap. suma again in
365 days; but as ye Apsis in ye position
has a progressive motion that retards
it in less yn 400. Therefore upon ye whole
ye inequality is much greater yn ye former wch
of ye Eccentricity: yt depends in like manner
upon these 2 Causes, viz ye position of ye
2 [illegible] of ye Apsides, & if ye variation of ye
vis Centripeta be greater yn in proportion
of ye ratio of ye Squares of ye Dist. ye Eccentricity
wd be encreas'd if in a less (Vide greg. astro. book 4 prop. 31) wd be diminish'd. But
in ye Syzygies ye anomaly is in a greater yn ye
above mention'd ratio in ye Quadratures
in a less, therefore ye Eccentricity wd be greatest
wn ye Satellite is in ye Syzygies & least in
ye Quadratures & wd be Constantly increasing
as ye Satellite moves fro ye Quadratures to ye
Syzygies & decreasing as it moves from
Syzygies to Quadratures. but as ye varia-
tion in Syzygies is double to yt in ye quadratures

ye Encrease of ye Excentricity wd be double its decrease, & Consequently on ye whole ye orbit wd at last by ye Cause alone wd Continually grow more ~~excentricall~~. 2dly as in ye former case ye Excentricity has been proved to depend on ye variation of ye vis Centripeta being in a greater yn a reciprocal ratio of ye Squares of ye dist. wch follows from ye nature of an Ellipt orb. & ye variation wd be greatest in ye place where ye Apsides are, since ye disproportion of ye dist. wd there be ye greatest, if therefore ye Apsides are in ye Syzygies ye variation wd most exceed ye reciprocal ratio of ye Squares of ye dist., if in ye Quadratures it wd fall most short of ye proportion, in ye first Case ye Excentricity wd be greatest in ye 2d case ye least & wd increase or diminish as ye Apsides move towards ye Syzygies It is ye inequality arising from ye last Cause wch ought [illegible] yt arising from ye first because the time in wch ye first Continues is a little so much shorter yn ye time wch ye last lasts. It appears likewise yt since ye variation of ye force above ye reciprocal duplicate ratio of ye dist. (wch causes ye Excentricity to increase) is double to ye variation of ye same ratio below ye reciprocal duplicate (wch diminishes ye Excentricity) ye Excentricity must on ye whole from ye Cause also Continually encrease. 334

With Regard to Errors caused by the Inequ-
alities we must take care of the
disturbing forces, of which is of any conse-
-quence, but those which act within the plain of the
satellites orbit and in a Line parallel
to the plane of the orbit of the primary if
the Nodes happen to be in the Syzygies
those forces which have no tendency to
alter the plane of the orbit; if they be
in the Quadratures then have the greatest
Effect: since in that case it will continually
draw the Body towards the plane of the primary
orbit which therefore the Nodes are in the
Syzygies as no disturbance in the plain,
the Angle of inclination will retain
its original Magnitude, but if they are

In ye Quadratures it wd tend to lift preserve ye body by ye Nodes ye Syzygies wd increase or diminish as ye Nodes were found in ye Syzygies or Quadratures. If ye Nodes bein ye octants past Quadratures, ye Change wd decrease in ye motion of ye body, thereby increase thro ye next 45 & decrease again thro ye next 45 wch increase or decrease is owing to ye decrease of ye bodys being of ye same or Contrary affection, wth respect to ye disturbing force. on ye whole therefore ye Inclination is more diminished yn in creased & is always least at succeeding ye Node proceeding Node, on ye Contrary if ye Nodes be placed in octants between Quadratures:

~~[illegible]~~

The Inclinatio is more encreas'd yn
yn diminish'd & Consequently greatest
subsequent ye at ye preceding then. hence
it appears since ye Angle of ye Inclinatio
lessens in ye regress of ye Nodes fro Syzygies
to quadratures & encreases in ye progress
fro Quadratures to Syzygies, yt at ye
Syzygies it wd be greatest at ye above
& least at ye Quadratures &c as ye Nodes
are progressive at ye same but wn ye
disturbing force pushes ye Moon from
ye plane of ye Earth's orbt & ye sd force
acts only in such a manner between ye
Node & nearest Quadrature it follows yt
wn ye Nodes are in ye Quadratures their
Motion wd be always retrograde since
therefore there is no place of ye Orbit in
wch ye force can act in ye direct manner

w^n they are in y^e Syzygies they have no 338
motion at all, y^e distancing from y^e placing
in y^e Planes ecc.; in intermediate places
they move sometimes forw^d sometimes
backw^d but on y^e whole their motion is in
Antecedentia for as we observed before
they never move forw^d untill w^n y^e body
is between y^e Quadrature & nearest Node.
y^e 3^d dis^t. by y^e greatest y^t can be, w^ch hap
pens w^n y^e Nodes are in y^e Syzygies it
takes up no more then 1/4 y^e Orbit.
in w^ch Case only they are stationary
if it be any thing less th^n y^e greatest it
does not take up half y^e orb^t & conse
quently y^e regressive is great^r y^n y^e
progressive Motion & this a greater
or less in proportion as y^e Nodes are
nearer to or further from the
Quadratures. ---

The Libration of ye Moon explain'd

65. ye Libration of ye moon is seen'd in longitudine & Latitudine · by her Libration in Latitudine is meant a Certain motion of her body ye means of which we sometimes see beyond her North pole & at other times beyond her South Pole her Libration in Longitudinem signifies a like motion Hiding & exposing her East & West limbs &c these Phenomena were discover'd by Hevelius & explain'd by sir Isaac Newton. — — —

66. First as to her Libration in Latitudine yt arises from the Inclination of her axis to ye plane of her orbt. for a person plac'd in ye Sun might see sometimes beyond ye North Pole sometimes beyond ye South Pole of our Earth; so as ye moon is in diff.t parts of her orb.t we can see some

times beyond ye North, sometimes beyond 340
ye South Pole; which wd (if ye Inhabitants
Inhabiting ye Sun might see beyond each
Pole yt of ye Earth 23°) we can see but
beyond those of ye Moon. because
its Axis is inclined a little Degree
vij. Her Libration in Longitudine m is
owing to ye Excentricity of her orbit; if
ye Moon had no Motion round her
Axis ye every pt of her body wd point
thus every revolution: again if she
moves round her Axis once ye same
way & in ye same time yt she turns
one revolution round ye Earth, ye same
pt of her (as wd be above) wd always
be turned towards ye Earth, but if she
moves faster on her axis yn which
wd turned towards ye Earth wd move
more Easterly, if slower more westerly.

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for by Imagining a meridian placed (at ye pt of)
over ye moon wch is turned from Earth
ye Meridian wch hang Easterly is wn ye
Moon is in her perigee because ye ends
move East & westly in her apogee
because they ye move. Thus much
for ye Phænomena of ye Moon; before
we speak of ye other Satellites we
shall explain, ye Eclipses of ye
Sun & Moon. — —

58. An Eclipse of ye Moon is a privation
of Light, in her occasioned by ye inter-
position of ye Earth between ye Sun &
& her: An Eclipse of ye Sun (or rather
of ye Earth, for properly speaking
there is no such thing as an Eclipse
of ye Sun) is a privation of Light.

in ye Earth occasion'd by ye interposition
of ye Moon between ye Earth & ye Sun. we
shall first speak of ye Lunar Eclipse.

67. A Lunar Eclipse can only happen at
ye full moon for it is at yt time only
ye Earth is interpos'd between ye
Sun & her, the not having Eclipses
at every full moon, is owing to ye
inclination of her orbit to ye plane
of ye Ecliptick: for it is certain yt except
ye Earth Sun & moon be all in ye
same plane, ye shadow of ye Earth
can never fall on ye Moon, but must
fall either above or below it, but they
are never all in ye same plane but when ye
Moon is in ye Nodes or else they are
turn'd towards ye Sun. there would be an
Eclipse every full if either ye Moon
was always in ye Nodes;

3ly must always be ye Plain of ye Eclipt[ic] 343
or those wch are not above [illegible] ye Nodes in ye [illegible]
her Nodes nearly by ~~[illegible]~~ [illegible] ye [illegible] ex
actly at ye time of her full.

4ly Hence it appears ye reason yt ye
Eclipses do not happen every year, some in
places of ye Zodiack but in succeeding
years gradually move backwd or
forwd ye different signs, for since ye
Nodes go backwd continually ye Eclips[es]
must do so too.

5ly 2ly When Eclipses usually happen twice a year ~~[illegible]~~
for ye Nodes are [illegible] twice [illegible]
twice a year [illegible] ye Moon [illegible] full [illegible]
[illegible] ye Nodes are
found [illegible] Trigonometrical
Calculation ~~[illegible]~~ of those [illegible] Eclips[es]

greater or less, According as ye Moon is
farther from or nearer to ye Nodes. ——

7°. The Conjunct Causes therefore of an
Eclipse happening wn ye Nodes are turn'd
towards ye Sun, we must Consider ye
Synodical Period wch is 29½ [illegible]
Mo[illegible] 30d [illegible] [illegible]
[illegible] [illegible] from ye Nodes wn they are
turned towards ye Sun; for Supposing it to
be new Moon ye same day ye Nodes are
turned towards ye Sun it will be in ye full
Moon both forwd & backwd: next
Suppose ye Nodes to be turned towds ye Sun
ye day before ye new Moon it will be
just 15d from ye new Moon & 14
backwd. Lastly Suppose ye Nodes turned
to ye Sun ye day after ye new Moon [illegible]

Hind or 14 days forw.d by ye full Moon
& 10 Backw.d so yt it plainly appears
there must have been a full Moon wth in
15d before or wd be wthin 15d aft ye Nodes
are turn'd to ye Sun. now suppose yt
she is at full any one day of ye 18 there
wd be an Eclips more or less therefore
time to on viz: 2 or 3 but there wd be an
Eclips every time ye nodes are turn'd to
wds ye Sun. — — — — —

43: Eclips of ye Sun are either tot.l or partial
ye Total are either Central viz: wth ye
Moon happen in ye Centre of ye Shadow
exactly or Penumbra: wn ye Moon happen
within or without ye Circle of ye Shadow: ye
Penumbral being ye past ye Eclips is so much
greater part of ye Moon is darkned or lapses
than ye Shadow of ye Earth's Atmosphere

Hence 'tis usual to Conceive [illegible]
ye Moon's Diamr as divided into 12 eql
pts call'd Digits, & ye greatness of ye particl
Eclipses are measur'd, they being sd to be of
so many Digits as there are pts Cover'd by ye
Earths Shadow: if 5 pts be cover'd 'tis call'd
an Eclips of 5 Digits &c.

74: The Shadow of ye Earth is of a Conicall fig.
growing Narrower & Narrower ye farther it
is Extended fro ye Earth till at Length it
Ends in a point. If a Person were plac'd
just at ye End or point of ye Shadow he cou'd
see nothing of ye Lucid Body except a
small ring of Light round abt it; ye farther
he's remov'd fro ye point ye Larger will ye
Ring of Light appear & Consequently ye less
will be intercepted by ye opake Body
till at last it will appear only as a point

or Spot w^ch ye Lucid Body as Bonds does 347
in ye Sun. If ye opake Sphere be less yn ye
Lucid ye Shadow w^ch is Conic^l. If both alike
tis Cylindric^l; if greater, w^ch ye latter is
Conic^l but in an inverted manner, so yt
ye Conic^l Shadow w^ch grows wid & wid^r as it
goes farther & farther & Consequently w^ch
run out in infinitu: yt may be call'd Conus
incrassans, as ye other Cuspidatus. Hence
why ye superio^r Planets for Instance (as it
is mentioned) are never eclips^d by our Earth
is because ye Conic^l Shadow ends in a point
before it comes to ye. ... ye Earth ...
... ye Sun for ever eclipsed so its Shadow
w^d never End in a point, but go on in
Infinitum. — — — —
450. We have hitherto spoke of ye Shadow
of ye Earth and Considering ye Shadow of ye
Planets,

w^ch is joyned to it; for y^e Shadow of y^e
Atmosphere is properly to be Conceiv'd in
Lieu of y^e Verge of Shadow of y^e Earth w^ch is
not reaching quite to y^e Moon: Now y^e
Atmosphere doth not Cast a perfect
Shadow, but only a weak Light, whereby
y^e Moon becomes visible in an Eclipse.
y^e Moon always entering y^e western side
of y^e Shadow w^th her Eastern side & consequently
quits it w^th her western side: there is always
a Penumbra of Darkness, w^ch attends such
Shadows, w^ch y^e Moon passeth thro before she
Comes to y^e perfect Shadow & after she has
quitted it w^ch is occasion'd by y^e interception
of y^e Suns rays by y^e opake Globe of y^e
Earth. but of y^e more below.

76. After y^e same manner as we have prov'd y^e
Moon must come into y^e Shadow
of y^e Earths Atmosphere w^n she is at or
near a Node, at y^e time of y^e full Moon
(i.e. in opposition to y^e Sun) it is also prov'd
y^t the Shadow must fall w^n y^e Earth
at y^e time of y^e new Moon (i.e. in Conjunct^n
w^th y^e Sun) provided she be in or near a Node.

But since ye Penumbra of ye Moons shadow 349
is much more sensible in Solar Eclipses
yn yt accompanying ye shadow of ye Earth
in Lunar ones it will not be improper here
to go any farther to give a more particular
acct of it. Let S be ye Sun, ye Moon & its
shadow falling on any place b.H. ye Places
b.p.q. wd be encompassd by a penumbra or diminishd
light; [illegible] ye places situated beyond b. [illegible] ye whole
Disk of ye Sun wd appear uneclipsd [illegible]
[illegible] a bare sight of ye Eclips: But as ye [illegible]
[illegible] H ye light wd be continu-
ally diminishd, i.e. ye Penumbra wd be
darker & darker: so as [illegible] ye
Sun wd appear ½ Eclipsd; going further [illegible]
[illegible] wd appear [illegible] so more ye
half dark, totally Eclipsd between ye H
[illegible] of ye Moon [illegible]
[illegible] ye [illegible] also wh wd easily appear
[illegible] without any farther Explication. —

44: The wid. of ye Shadow at ye G[illegible] at ye same place 350
of Eclips is [illegible] & ye Cone & ye Sun is totally
Obscure: but ye breadth is diff. according to
ye Diff. dist. of ye Moon fm ye Earth, & ye Earth
fm ye Sun. whence it sometimes happens yt when
ye Earth is in perihelio & ye Moon in Apogæ
ye Point of Shadow of ye Moon doth not reach ye
Earth, only keeps ye [illegible] in wch
Case ye Moon wd not quite Cover ye Sun tho
ye Eclips is Central but a bright [illegible] rim
all round. Such an one is Call'd an Annular
Eclips.

45: Tis observed yt [illegible] of ye Earth
Solar Eclips don't happen so often as Lunr
ones; wch is owing to ye Shadow of ye Moon
being less yn ye Shadow of ye Earth; for ye Shadow
of ye Earth commonly Covers all ye Moon
but ye Shadow of ye Moon can't cover all ye
Earth but part; sometimes [illegible]
sometimes [illegible]

+ for ye Sun's [illegible] Diurnal [illegible] [illegible]
[illegible] of ye Moon's [illegible]
[illegible] must be more [illegible]
of ye Moon.

× [illegible] Eclips[illegible] of y^e [illegible] 351
of y^e Moon In general [illegible] determin
[illegible]
Eclips. of y^e Moon [illegible] Moon's
shadow as it passes along in his Eclipse
because it falls [illegible]
[illegible], but did it fall perpendicul-
ar [illegible] ½ [illegible] circul^r [illegible]
Eclipse [illegible]
because [illegible]
[illegible] an Ellipsis. —

Of y^e Satellites of Jupiter & Saturn

49. The Satellites of ♃ & ♄ are subject to y^e same
inequalities as our Moon. those of ♃ which
turns by reason of their great dist. are not
Convenient for Observation [illegible] Eclips.
much [illegible] y^e our Moon [illegible]
[illegible] because they move much faster [illegible]
[illegible] period [illegible]

in one day 3 hours. 2dly because they are 352
very considerably nearer their primary.
ye Moon is dist. from ye Earth 30 Diamrs;
whereas ye next Dist. of a Satellite is only
of [illegible] fro. Jupiter [illegible] & ye nearest [illegible]
about 3. —— ——

§3: Amongst ye bodies yt accompany Saturn
he is observed to be surrounded wth a Ring
([illegible])
at a small dist. fro his body. ye Diamr of it
being double yt of ♄ [illegible]. as to ye
Cause of ye Ring [illegible]
Dark. Some imagine ye body of ♄ formerly
to have been bigger & yt [illegible] it was since
fallen in [illegible] ye Ring, just as if ye [illegible]
Earth should fall in [illegible] a Ring round ye Earth
wch might be supposed [illegible]

§4 This Ring is observed to [illegible] dist. [illegible]
[illegible] ye Earth. wch Gallelio [illegible]
its Edges turned tow. ye Earth;

so yt nothing else to be discover'd but 353
wt are on either side of Saturn wch are to be
called the Ansæ or Handles.
Huygens wt ye first who discover'd it to be
an Entire Ring; for he found yt those
Ansæ grew blunter & blunter & Saturn
appeared more of a roundish fig.; till
at last it wt turned into such a position
yt he saw clearly ye whole of ye Ring.
He discover'd also yt it wt inclined to ye
plane of ye Eclipt. in an Angle of 31
intersecting it in ye first point of Pisces
& Virgo. Therefore as often as Saturn is
found in ye Nodes of ye Ring i.e. in those
signs he must appear destitute of it.
For wn ye Sun is shining on ye narrow
Ring, so [illegible] ye thickness of it [illegible]
[illegible]; ([illegible] not light enough
to be visible at a dist.)

'Tis plain that nothing of it can be seen 354
but a small Track or Shadow as it were
crossing his Body. 'Tis manifest also yt ye
Ring must be invisible as often as ye plain of
ye Earth [illegible] ... as yt ye plain of ye
Ring produced will pass between ye [illegible] for ye bright
is ye obscure Surface placed so as to be
placed to ye Eye of ye observer. But accord-
ing as ye [illegible]
ye nodes of ye [illegible] of ye Ring [illegible]
[illegible] ye Eclipses of ye
Heavenly Bodies especially of ye Satellites
of ♃ being reckon'd of greatest use in determini-
ng ye Geographic Longitudes of places,
we shall next give an acct of ye famous
Problem & ye methods yt are (some illustrate) us'd to solve it.

Of ye Geographical Longitude and Latitude of Places.

82 The perfection of the Art of Navigation depends
upon the Mariners being able at any time
whatever to determine exactly the Point
of the World he is in & to know the way he is
to steer his Course. His Latitude, or how
he is removed North & South, he can
easily find by measuring the Elevation of the
pole above the Horizon, which is the same as the
Degree of the Equator. thus it is easy to know
at parallel he is in, but the diff. is to know
how he stands in respect to East & West. i.e.
what Meridian he is under. amongst all the
Methods made use of to resolve this problem
there is none better than Celestial Phenomena
[illegible] but before [illegible] it is necessary that
a few things be premised, wherefore we must
observe that the [illegible]
or some Circle parallel to it with an equable
motion in the Space of 24 hours,

Consequently in places we suppose are 15° 356
of [illegible] which noon
or 12 a Clock und^r any Meridian, they
who live 15° west of y^t w^{ch} count it ~~but~~ 11
of y^e Clock, they who live w^e East w^{ch}
Count it 1 a Clock in y^e Afternoon
& of y^e times of y^e Day w^{ch} vary proportion-
ally at all Dist. East & West.

83. [illegible] of y^e same in Instances Celes-
tial Phaenomenon w^{ch} is fixed to one
Moment of Absolute time alike visible
in all p^{ts} of y^e Earth, be pitched upon:
we may refer y^t one point of Absolute
time to y^e ordinary time of any particular
place & reckon y^e diff^t designations of
y^e same moment of absolute time in
diff^t parts of y^e Earth, in hours, Minutes,
& seconds, we may Come to know y^e diff. of y^e
Meridians or y^e diff. Longitudes of
places.

For Example If a Phænomenon be Calculated to appear at London Exactly at Noon, & it be not observed at Sea till 1 a Clock, it is plain y^e ship is 15 deg^s Westward of y^e Meridian of London; if at 11 a Clock, y^e ship is 15 or as many degrees Eastward of it.

84. Some such Phænomenon is still wanting. y^e middle moment of Lunar Eclipses &c. as often as such Eclipses happen, w^ch is so very seldom, y^t y^e method is almost useless: y^e best Phænomena as yet discovered are y^e Eclipses of 4^s Satellites, w^ch are instantaneous Phænomena (in y^t they are visible to all p^ts of y^e Earth at y^e same moment of absolute time) very easily Calculated for any Meridian by Tables: Besides its a great Chance both against Eclipses every day, so y^t these Satellites may serve for y^t purpose daily if they are not proper

Without exact Ephemerides or Computations of all their motions. ye Satellites of Saturn will not so well, because they are not observed without much difficulty, besides there are not yet exact any Ephemerides of them.

68. The Chief point, wherein ye method is defective is ye want of an exact measure of time equable & Invariable, wch nothing since ye discovery of ye Clocks or watches ye make use of yet wrong ye Calculation is the wrong i.e. ye most exact measure of time we know of at present is ye Pendulum, whose vibrations are found to vary in almost every Latitude. besides tho ye method may serve well enough to determine ye Longitude of places by Land where we can have ym fixing, it is however almost Impracticable at Sea, where yet ye Longitude is most wanted; ye Rocking of ye Ship rendring such large Telescopes as must be made use of in those observations useless.

Observ. of ye rev. of Comparatio of 4 wth ye Sun then
Eclipse are invisible for some months.—

Of ye Crepusculum & ye Circulo-polar,

807. The Crepusculum is ye Twilight or Light
wch we receive before ye Sun-rising & after
Sun setting. Its arising from ye Atmosphere
or splendid Lights surrounding him wch rises
before & sets after him; but chiefly from ye Atmos-
phere of ye Earth whose vapors wch are Illu-
minated by ye Suns Rays before & after ye
Sun appears above ye Horizon. It's not
always of ye same degree of duration or
brightness, but gradually rises till ye Sun
is 18 below ye Horizon & appears as long
before its rising in ye morning it holds
longer in summer time yn in winter because
in summer ye Atmosphere being rarified by ye
Heat of ye Sun expands itself in altitude
& by reason of its greater height, can inter-
cept & refract more lines of ye Suns Rays reflect-
ed towards ye Earth; for ye same reason
ye evening twilight is longer yn ye Morning

for ye Atmosphere is rais'd high by ye heat 360
ing ye day time, falls Covering ye Night

54. The twilight is shortest neer ye equator, because ye Sun setting at right Angles wth ye Horizon is sooner gone 18d beneath ye Hor: when ye Sphere most oblique ye (in our Latitude) for some pt of ye Year ye Sun is never above 18d below ye Horizon, owing to it for ye time we have no Night but Continual twilight. in places wch are above 18d in Latitude ye twilight is perpetual; for ye Sun Never goes 18d below ye Horizo:

55. Neither is ye Appearance of any of ye Stars [illegible] [illegible] for ye rays passing thro' ye medium of ye Other it must (according to ye Laws of optics) [illegible] rays coming from ye Celestial bodies to [illegible] inclination there being [illegible] visible before they really are above ye Horizon & increase in their height after they are above it. In ye Zenith there is no refract. because [illegible] perpendicular ray [illegible] & it is imperceptible [illegible] at [illegible] [illegible] degrees from ye Zenith [illegible] refraction is [illegible] [illegible]

as ye Sun & Moon appear near Ellip.l fig.
when near ye Horizon their Inferior Limb
being Elevat.d by ye Refractio of ye Atmos.e
a great deal more than ye Upper.

Of ye Fig. of ye Planets.

89. That ye Sun & Planets are Spheric Bodies
as ye Earth is Spherical may not only be prov'd
Empirically, but also by ye Nature of those
Laws by w.ch ye planetary Syst. is govern'd
for since all ye Planets Primary & Secondary
Consist of Matter whose Particles mutually
gravitate to Each other, it follows that they
[illegible] naturally affect a spheric fig.
since a [illegible] of [illegible] [illegible]
[illegible] spheric [illegible] [illegible] of Parts
of its body, its spheric fig. is also prov'd
by ye various Elevations & Depressions
of ye [illegible] in diff. Horizons, w.ch w.d not be in
ye Earth of another fig.:

tis observ'd [illegible] yt in all Lunar eclips: ye
Shadow is bounded wth a Circular Line, whe-
ther ye Shadow proceeds fro ye Earth itself
or fro its Atmosphere (the latter is indeed
ye truth) it matters not; for if ye Atmosphere
be Spherical, ye Earth wch is inclosed in it must
be so too. but tho all Astronomers affirm yt ye
Earth is a Sphere yet they don't mean a perfect
geometrical Sphere; but an imperfect one or
rather a prolate Spheroid: yt not only ye Earth
but almost all other Planets are of yt fig:
(arising fro their violent Rotation round
their own Axeis wch endeavours to throw of
ye Equinoctiall parts we have already proved
(in Hydrostaticks. sect. 36. 37. 38) therefore
here we shall only observe yt by reason of ye
Spheroidic. fig. of ye Earth, Heavy bodies do not
tend to ye Center of ye Earth in Lines perpendicular

[illegible] of ye [illegible]
[illegible] ye Sphaeroidicall fig. of ye Earth Caus
ye [illegible] of ye [illegible] & Consequently
ye precession of ye Equinoctiall points which
we come next to treat of. — —
The precessio of ye Equinoxes acc. for.
The [illegible] of ye Axis of ye Earth always
kept ye same parallelism [illegible]
[illegible] axis is agitated wth a conical motion
so as to describe 2 cones vertically opposite
to one another having ye 2 vertexes in
ye Center of ye Earth. ys motion is perform'd in
antecedentia Causing ye poles of ye Earth
[illegible] round ye poles of ye Eclip. in 25920 yrs
[illegible] is called ye greatest year. & as ye Diurnal
rotation from West to East causes an apparent
diurnal revolution of ye whole Sphere from
East to West so ye other [illegible] revolution of ye
Earth in antecedentia causes an apparent

Motion of ye fixd Stars in Consequentia round ye Poles of ye Ecliptick in ye space of 25920 years. Since ye Axis of ye Earth is always perpendicular to ye plane of ye Equator [illegible] which [illegible] it follows yt by ye apparent motion of ye Earths Axis, ye Centers in ye section of ye plane of ye Equator wth yt of ye Ecliptick (i.e. ye Equinoctial points) must move round ye Ecliptick in ye space of 25920 years. whereupon in ye space of 12960 years wch is 1/2 ye great year, ye seasons of ye year wd be quite inverted; midsumr wd happen in Decembr & Midwintr in June: & in 12960 yrs more they wd come round to ye same times of ye year again. Thus these 3 Phænomena ye Motion of ye Earths Axis, ye revolution of ye fixd Stars & ye regression of ye Equinoctial points are only diff. conceptions of ye same Phænomenon by Astronomrs termd generally ye precession of ye Equinox. —

91. The Solution of ye Phænomenon is ascribed
wholly upon ye Ellipticall character of
ye Spheroidicall figure of ye Earth, ye Earths
Equator it self being encompassed as it
were wth a Ring: ye Regression of ye Moons
Nodes has been already accounted for upon a
supposition ye Sun lay out of ye plane of
her orbit. Let us now suppose more Moons
revolving in ye same orbit in eqll times:
to explain how ye Nodes would be agitated by a mutual
motion & ye motion wch ye Sun impresses on every
one. Let there be so many as to touch
one another & forming a ring, ye Nodes of ye Ring
must for ye same reason move backwards:
Lastly let ye Ring be fastned to ye Globe
(yet retaining its impressed motion)
to keep it from falling [illegible]. but now being
joynd to ye Ring must in some measure
partake of ye Motion of ye Ring whose Nodes
will yet go backwards;

but much slower & ye Case is ye same in a Globe without a Ring which is either some thing higher in ye parts about ye Equator or consists of a denser matter; for ye excess of matter in ye equatorial parts supplies ye place of a Ring. having now dispatched ye various Phænomena of ye 16 planets we shall in ye next place treat of ye Reall motion of ye Sun.

92 It appears from observations made upon ye Spots of ye Sun, yt ye Sun hath a motion round his Axis in ye space of about 24d. neither is yt ye only motion He is subject to; for it follows from ye Nature of Universall gravitation & ye Equality of Action & reaction yt he must be influenced by ye Actions of ye primary planets & Consequently not only revolve about its own Axis but also round ye Comon Centre of gravity of ye whole planetary System; but since tis observable from Calculation yt ye Centre of gravity very ~~nearly~~ nearly Coincides

wch ye Centre of ye Sun, tis plain yt ye latter motion must be insensible, we come now to enqr concerning ye absolute dist of ye Heavenly Bodies but since their dist are measured by ye semidiameter of ye Earth it will be absolutely necessary first to know ye reall length of ye Semidiameter; wherefore we shall next give an acct of ye severl methods made use of to Measure ye Diameter of ye Earth.

93: The methods made use of to measure ye Dimens of ye Earth are either terrestial or Celestial. ye Chief terrestial methods are those of Eratosthenes or Maurolycus &c. Eratosthenes observed yt at ye City Syene ye Sun was perpendicular on ye Day of ye Summer solstice, but at ye City of Alexandria situated almost under

Fig. ye same Meridian wth ye former it was 7° $\frac{1}{2}$ from ye Zenith; from wch data he determined ye Diameter of ye Earth Let A be ye City Syene;

B Alexandria where ye gnomon BG is per-
pendicularly erected, let DF & EG. be ye Rays
of ye Sun Physically parallell — DA per-
-pendicular to Syene, EG oblique to Alexandria
making wth ye top of ye gnomon ye Angle
GCB = $7^{\circ}\frac{1}{2}$ now since (by Eucl. 29 prop.
2. 6. o.r.) ye Angle GCB = AFB & ye measure
of it is ye Arch AB wch may be known by
Mensuration (viz: ye dist. between ye 2 Cities)
we found ye Compass of ye Earth by ye Rule
togy. as $7^{\circ}\frac{1}{2}$: AB :: 360d = ye Compass of
ye Earth; in Miles or whatever measure was
made use of in measuring ye dist. between
ye 2 Cities. — — — —

94: The method of Maurolycus, wch is yt ye
Altitude of a mountain AD be known
& AB ~~both~~ ye Line touching ye Earth at B
fig:10 (at ye extremity of wch ye mountain begins
to disappear) be known also by measuring
bisect DE in C & draw BC (by el. 2 prop. 6)
ye rectangle under AC, AD with ye Square of DC

will be ye excess of ye square of AC; but ABC is a right triangle therefore ye square of AC will be = ye sum of ye squares of AB & BC. take away from both sides ye squares CB & CD (wch are eqll as being radii of ye same Circle) & there will remain ye rectangle AC × AD = AB² wherefore Divide ye known square AB by ye known measure AD ye Quotient will be ye Line AC from wch subtract AD & there will remain ye Line DE is ye Diamr of ye Earth. ---

95. As for ye Celestial methods, wch are (capable of far greater accuracy yn ye Terrestrial) their general intent is yt of their Altitudes of ye pole in 2 several places situated directly under ye same meridian being found they may by actual mensuration find also ye dist. of those 2 places, in Miles & Furlongs

According as it appears fro ye most diligent 370
Observations of Mr Norwood yt 139 Miles
Answr to 2° in ye Heavens wch is at ye rate
of 69 ½ to 1°. therefore ye Circumference
of ye Earth is determined by these propor-
tions 2° : 139 miles :: 360° to ye Circumfer-
ence of ye Earth in Miles ye Norwood right.
fro all these Calculations it appears yt ye
Circumference of ye Earth is in round
Nos 25000 English Miles & Consequently
its Diamr (wch is always as 113 to 355) nearly
is in round Nos 8000 Miles & its
Semidiamr 4000; of ye parallaxes &
Absolute dist. of ye Heavenly Bodies.
Def: The parallax of a Heavenly body is ye
dist. between its true & apparent place
in ye Heavens of wch true place is ye point
in wch its seen fro ye Center of ye
Earth & ye its apparent place ye point
in wch it is seen fro some pt. on ye surface of
ye Earth.

fig: 11: Let H, h, represent ye Earth its Centre, C L

ye plane of ye orbit of ye Moon; D R ye plane of ye orbit of

one of ye Planets, a, a portion of ye sphere of ye

fixed Stars & a, ye plane of ye Spectator on ye

Earth; Let ye Moon be in G, i.e. in ye sensible

Horizon of a, by ye known Law of opticks

an observer at h, wch refers ye Object to ye point A

will be removed fro ye Centre & it will be referred to

ye point D wch is ye true place, ye Arch A D

will be ye parallax of ye Moon, & Angle A G D

ye parallactick Angle; ye parallax also

may be expressed by ye Angle under wch ye

semidiameter of ye Earth appears to any Heavenly Body.

11: further Demonstrated from a sight of ye fig:

yt if ye parallax be consider'd with respt.

to diff: Celestial Bodies, it is greater or less

as these Bodies are less or more Distant

fro ye Earth: thus ye parallax A ... is greater

yn ye parallax A ... of ... [illegible]

If the appart^t lo of y^e same Body it is plain y^e Hori-
zontal parallax is greatest of all & y^t it is
diminish'd gradually as y^e Body is rais'd
higher above y^e Horizon. thus AB & Ab
y^e Horizontal parallaxes of G & g, are much greater than y^e Parallaxes of ye Vertical ... &
& lastly it vanishes in y^e Zenith y^e same line
denoting y^e true & apparent Place there. It
may be observed y^t as y^e Stars are Elevated
by refraction, so ~~they~~ on y^e contrary they
are depress'd by y^e parallax.

78: The only use of knowing y^e parallax of a
Star is to find thereby its dis^t from y^e
Center of y^e Earth w^ch is easily done
by y^e Rules of Trigonometry, thus for
Instance if y^e Dis^t of g be sought if
side A... & y^e Angle ... of y^e triangle ...
being determin'd by observation y^e side ...
will be found: but if any other be above
15000 Semid^rs of y^e Earth its Horizontal parallax

still be insensible; for if Sin: 1'' : 15000 373
:: viz: if ye Radius of ye parallactick
Angle be to ye Sine as 15000 to ye Angle
of 90: it will be invisible for it will not ex-
ceed 13'' a quantity too minute to
come into ye Cognisance of ye finest In-
strum.ts Hence ye parallaxes of none of ye
plan.ts except ye Moon can be exactly
determind nor even with any great
Certainty so as to be free of all mistakes.
ye parallax of ye moon is found by ob-
serving her at 2 diff.t Stations along
when she is at ye same line vertic.l to
one ye Horizon & to another; it is found
determined to be ab.t 57' her dist. conse-
quently ab.t 60 of ye Earths Diam.r
27: But ye Suns parallaxe can't be taken singly
as ye Moons may for 2 reasons, their dis-
tance at least 15000 Semidiam.rs of ye Earth
his parallax must consequently be so
small as to escape ye Notice of ye best Instruments.

Neither 2dly can ye Sun & fixd Stars be
viewd together but notwithstanding yt
there have been severall methods proposd by
ye Ancients as well as Modern Philosophers
to find it out but most of wch have proved
imperfect. we shall give a brief acct of ym
& shew their deffects. 1st ye Method of Hipparchus
depends upon ye observation of ye Lunar
Eclips & is founded upon these principles
100: First yt in a Lunar Eclips ye Horizontal
parallax of ye Sun is eql to ye diffr between
ye Apparent Semidiamr of ye Sun & ½ ye
Angle of ye Conical Shade wch is thus de-
2.12 monstrated. Let S be ye Suns disk, ye
Centre, E ye Earth, C ye Centre EM ye
Conical Shadow, EMC ½ ye Conical Angle
tis plain yt ESE is ye Horiz parallax of ye
Sun (i.e. ye Angle under wch ye Semidiamr
of ye Earth is seen from ye Centre of ye Sun)
& ACS ye Appart Semidiamr of ye Sun. Now
(by El. 1.32) ye Extern. Angle AES is = C

be y^e 2 internal opps EHC & EMC: therefore 375
EHC — HES — EMC. Q.E.D. ——

131. 2. The ½ y^e Angle of y^e Cone is eq^l to y^e diff. of y^e Horizont^l parallax of y^e Moon & y^e Apparent semidiam^r of y^e Shadow of y^e Earth at y^e dist. of y^e Moon, w^ch is thus demonstrated in y^e same figure where ED represents y^e Earth; C y^e Centre, & y^e Circle ZH be y^e Section of y^e Shadow at y^e dist of y^e Moon; & let y^e Diam^r of y^e Shadow, lie plain at HZ; ∠ HCZ y^e Angle und^r w^ch y^e semidiam^r of y^e Sect. w^ch be seen at y^e Centre of y^e Earth, EHC is y^e Horizont^l parallax of y^e Moon or y^e Angle und^r w^ch y^e semidiam^r of y^e Earth is seen at y^e Moon & EMC, as before, y^e Angle of y^e Cone. Now by el. 1.32, y^e Extern^l Angle EHC is eq^l to y^e 2 intern^l opps HCM & HMC; therefore half y^e Angle of y^e Cone or HMC = EHC — HCM. Q.E.D.

132: To apply y^s it appears farther Moreover y^t if to y^e Apparent Semidiam^r of y^e Sun there be added y^e apparent semidiam^r of y^e Shadow

& yt is ye Sum of ye 2 Horizontall Parallax of ye Moon ye Remaind wch is ye Horizontall Parall.x of ye Sun. is: AES. ± HCL = EHC = E.L. for instance let AES be 16: HCL 44,30 let EHC be 60,15 yn 16 × 44, 30 = 60,30 = 60,45 = 15 wch is ye Horizontall parall.x of ye Sun, so yt this dist of ye Earth wd be 13700 semidiam.s of it. 376

153. This is ye method of Hipparchus, wch tho it were all ye way Mathematicall demonstration is yet defective chiefly in ye following pticul: 1st he takes ye Horizontall parall.x of ye Moon for known, wch yet is impossible to be known with yt great accuracy, yt Hipparchus's method requires. 2dly 'tis impossible to determine Exactly ye semidiam.r of ye shadow or indeed of any other of ye Angles in ye Diagram wch if it be not done with ye greatest exactness Imaginable may occasion such errors in Computing ye Quantity of ye parall.x as shall exceed even ye parall.x sought. —

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Upon these Accts ye method of Hipparchus
is generally laid aside. ——
14 In ye room of yt Method Aristarchus
Samius contriv'd another (wch was afterwds
renew'd by Kepler, Vendeline, & especially
Ricciolus, Astronomrs of ye last Century)
But yt also is insufficient, he thought yt the
ye Semidiamr of ye Earth bears little or no
proportio to ye vast dist. of ye Sun yt to ye
Semidr of ye Lunr orbit perhaps might;
he try'd therefore to find out wt diffce
there might be of ye positio of ye Sun as seen
fro ye Earth & seen fro ye Moon wch diffce
as ye rest of distinction call'd ye menstrual
parallx. Let S be ye Sun (fig 13) T ye Earth
A R a Quadrant of ye Lunr orb. L ye
Moon be bissected in one of her Quadratures
then ye Angle SLT wd be right. Let ye Angle
LTS (ye elongatio of ye Moon fro ye Sun)
be known also by observatio; yt wd
also give ye Angle TSL so yt wth having
Triangle

L.S whose 3 Angles (or the 2^th one of its) 378
sides are known w^ch side is S.L. for w^ch
data y^e side S.L. (y^e dis^t. of y^e Sun fro y^e Earth)
is easily found, but y^e difficulty is to tell
y^e mom^t. w^n y^e Moon is bisected; for it
appears halved for 2 hours together
in w^ch time any mom^t may be taken
for y^e true time of dichotomy, as well as
another as for y^e infinite diversity of mo
ments of time we sh^ll have infinite di
versity of dis^t. of y^e Sun fro y^e Earth &
Consequently y^e true dis^t. of y^e Sun fro
y^e Earth canot be determined by y^s method.
158. y^e 3^d way of finding y^e parall^x of y^e Sun
is by y^e investigatio of y^e parallax of ♂.
for since we may Easily gather fro y^e
Copernican System y^e true proportions of
y^e dis^t. of y^e sever^ll plan^ts fro y^e Sun, it foll
ows y^t if we can but obtain y^e parall^x
of any one plan^t we have in eff^t. acquir'd
y^e parall^x of y^e Sun itself. ♂ w^n he is
Achronical (or opposite to y^e Sun)

is twice as near Us as ye Sun is & Conse- 579
quently his parallx is twice as great as ye
Suns. in ys position he wd not long ago w.th
he wd observ'd by Flamstead at Greenwich
& Cassini at Paris, who both determin'd of
his parallx wn ye Sun was 30" y' of ye Sun 11"
& his dist. ab.t 19000 Semidiamrs of ye Earth.
105. Hooke & Flamstead both affirm yt ye Ann.l
parallx of ye Dog-star (or ye dist. of ye 2 Earth
In June & December wth ye diff. of their dist.)
is 24" whence it follows yt ys Star is dist. fro
ye Sun 9000 Semidiamrs ~~of ye~~ Orbis Magnus.
104. Dr Halley has shown us a method to find
out ye Suns parallx much more accurate
yn any of those mention'd. tis grounded
on ye Body of ♀ passing thro ye Disk of
ye Sun, wch wd happen May 29. 1761 if
ye Eclip. be observ'd fro severall pts of ye
Earth, each observr wth see ye Body of ye
plan.t enter upon & go out of ye Suns Disk
(at a diff.t time wch diff. of time wd arise
fro ye planets parallx. if therefore ye
Journals of ye observrs be diligently
Compar'd ye parallx of ♀ & by

Consequences of parallax & hence dist. of ye Sun may be determined wthin a 150th pt of ye whole. if it be ask'd why ♀ wd not do for ys as well as ☿ especially since she is oftner found in ye Disk of ye Sun yn ☿, it must be Answd yt Mercury being very near ye Sun has parall. diff. so very little fro ye Suns as to escape ye nicest observations; whereas ♀ wn She is in her Inferior Conjunction is at Least 4 times as near us as ye Sun. Vid. Long. Sect. —

Of Comets. —

108. Comets are a kind of planets moving periodically round ye Sun; their orbits are Elliptical, having ye Sun in one of their foci; and so very Eccentric as to differ very little fro right Lines; but their orbits as to ye absolute Situation & Inclination as well in respect to one another as to ye orbits of ye planets are various. their Motions also are very Irregular; some moving like ye planets from West to East, others from North to South and Easterly others fro South to north. ye great Comet in 1680 Came so near ye Sun yt according to Sr Isaac's Newton Calculation,

the Heat it there by Contracted was
2000 times greater than that of red hot Iron,
& that if its Body were of the bigness of our
Earth it cannot cool again in a Million
of years.

109: That Comets are generally accompanied
with Tails or Large Streams of Light
Issuing out from the Nucleus or Body of the
Comet; which is Conceived by Sr Isaac
Newton to be nothing else than thin Vapours
forced out of the Head of the Comet by the
Heat of the Sun & that whilst the Comet is in
its Aphelion or at its remotest distance from
the Sun, those at that time are sunk down
& are equally diffused over the Comets Atmos-
phere: but while it draws nearer & nearer
to the Sun they being more & more ra-
-rified by its heat, ascend & fly off
the very way which is from the Sun. hence we
see the reason why the Tail of a Comet
is always turned from the Sun & why it
increases as the Comet approaches to the

Sun & diminishes as it recedes fro it.

110. Sir Isaac Newton's opinion of ye Tails of ye Comets may be best gathered fro ye 3 following passages wch occur in his principia l: 3. prop. 40 —— Caudæ igitur Phænomena
" non fiunt ex refractione Cœlorum, sed a ca-
"-pite suppeditante materiam oriuntur;
" Etenim ut in aere nostro fumus corporis
" cujusvis igniti petit superiora, ita hæc in
" Cœlis ubi corpora gravitant in Solem,
" fumi et vapores ascendere debent a Sole
" et superioria petere. ——
" Ascensum caudarum a Sole Keplerus ascri-
" -bit actioni radiorum lucis materiam
" caudæ secum rapientium. Suspicor autem
" Ascensum illum ex rarefactione materiæ
" Caudarum potius oriri. Ascendit fumus
" in Camino impulsu aeris cui innatat,
" aer ille per calorem rarefactus ascendit
" ob diminutam suam specificam gravitatem et

„ fumum implicatū rapit secum. Quidni Caudæ 383
„ Cometarū ad eundē modū ascenderint
„ a Sole? Nā radijs Solares non agitant
„ media, quæ permeant nisi in reflexione
„ et refractione; particulæ reflectentes
„ ea actione calefactæ calefacient aurā
„ ætheream cui implicantur, illa calore
„ sibi communicato rarefiet et ob dimi
„ nutam ea raritate gravitatē specificā
„ qua prius tendebat ad Solem ascendet
„ et secū rapiet particulas reflectentes
„ ex quibus cauda componitur. ad
„ ascensum + Crassum conducit etiā vaporū
„ quod hi gyrantur circa solem et ea
„ actione conantur a Sole recedere. –

III. Hence it appears th^t y^e his opinion
in short is y^t ; y^e tail is smoke in our at-
mosphere because its specifick
gravity is less y^n y^t of y^e surrounding
air; or rather because y^e air w^ch is
mixed w^th y^e smoke being heated

& consequently rarified & rendered speci- 384
fically lighter yn ye rest of ye Collateral Air)
by ye warmth of ye body, wch emits smoke;
I say as ye rarified Air rises up & carries ye
intermingled particles of smoke up along
wth it to ye top of ye Atmosphere; so ye tails
of Comets, (wch are only very thin
Vapours exhaled out of ye Nucleus
or Body of ye Comet by ye heat of ye Sun)
being warmed communicate their
warmth to ye Ether (or fluid medium,
wch he supposes to be diffused thro out
ye whole Solar System & beyond it)
next adjoining to it wch accordingly
by ye means rarefied & becoming
thereby specifically lighter yn ye
rest of ye Collateral Ether is buoyed
up by it carrying ye intermingled
Vapours of ye Comet up along wth it into
ye regions of ye Heavens opposite to
ye Sun. Add to yt yt ye Circumgyration
of ye Comet round ye Sun may make these
vapours fly [illegible] along wth it;

and by its means conduce something to their ascent. This seems to be the summ of Sir Isaac Newton's opinion; but here it may be doubted whether this account of the ascent of the tails of the Comets from the Sun is not improbable and even contradictory to Sir Isaac Newton's own principles laid down in other parts of his writings.

112 ~~For first. Were it possible that the Rays of the Sun reflected~~

And by yt means Conduce something 385
to their ascent. yt seems to be ye sum
of Sir Isaac Newtons opinion, but
here it may be doubted whether ye
acct. of ye ascent of ye tails of ye Comets
fro ye Sun is not improbable & even
contradictory to Sir Isaac Newtons
own principles laid down in
other pts of his writings. — — —
11th: Query 3d: were it possible yt ye rays of ye
Sun reflected from those exhalations
cd cause such a partiall rarefaction of ye ambient æther
as is here supposed; it may very probable be
possible yt every part of ye tails ought to be turned
towards ye Sun. for Sir Isaac at ye latter end
of his opticks asserts ye æther to be rarest
within ye Body of ye Sun & denser & denser in pro-
portion as its more distant from it. now if yt be
true its certain yt these tails ought according
to ye Common Laws of Hydrostaticks

~~to~~ to be carri'd tow.ds ye Sun. for ye fluxion. 1386
Ether, wch is their Vehicle being exhypothesi
specifically light.r yn ye rest of ye Celest.l
Ether ought to retreat into these pts
wch are of ye same specifick gravity wth its
& its, it ought to be carri'd tow.ds ye Sun &
Cause ye tails of ye Comets to be turn'd from
113 But sd we suppose ye Ether to be denser
near ye Sun Contrary to wt Sr Isaac Newton
asserts in his Hyp. it wd yet be impossible
there sd be any such partic.r rarefaction
of ye Ether as must here be suppos'd. for
if ye reflect rays can warm ye Ether to
such a degree as to alt.r its specifick
gravity; certainly its direct ⓑ rays
ought ⓑ eq.lly to warm & rarify all pts of it yt are
at eq.l dist.! But a total rarefaction can
never produce such an eff.t as is here
requir'd; for in case of a total rarefaction

there can be no following in ye Celestial 387
Æther, yt Æther wch is impossible ye Vapours
sd be buoyd up to such a prodigious dist.
fro ye Body of ye Comet. to suppose ye that
Æther springing fro' by its Elasticity
wch runns into ye Absurdity of supposing
ye Æther continually flowing into ye Solar
System; so yt in some ages more it must
be quite cleared of any other at all & ye
Sun Consequently ye ceas'd of Commu
nicating to us any heat at all: as wd appear
fro' wt is to be sd below in speak. of ye Clouds
114. 3dly If we grant ye Æther capable of so repelling
little wd be gaind for since these vapours
are of a substance so extreamly rare yt they
transmit ye light of ye stars wthout any
sensible diminution & are scarcely dis
tinguishable even when they appear
most raird. it is not possible they sd reflect

rays enough because any Imaginable
warmth in ye Æther, tis a millionth part
wch is some thousd times less yn those
Exhalations can communicate little or no
heat to ye Æther wch appears from ye great
Coldness wch is observed on ye tops of high
Mountains reaching beyond ye Zone; wch
are generally so cold as to be scarce born
therefore to consider Exhalations (wch
sometimes run out into tails far beyond
ye orbis magnus) can have any sensible
Effect on ye Æther. —

1154. 4thly Were it possible for these vapours
to warm ye Æther it is yet very improbable
yt ye Æther should be capable of being warmed
at all or (wch is ye same thing to us)
being rarified by heat. in ordr to prove ye[?]
it must be laid down firstly yt Æther is
ye medium whereby heat is communicated
from one body to another & yt all hot
bodies communicate heat according as

With ye immediate Contact, they do it by
Exciting very quick vibrations in ye
Æther included in ye pores; wch Vibrations
being propagated much after ye same manner
yt sound is in Air, at last ye Æther inclu-
ded in ye pores of ye Cold Bodies comes to be
set a vibrating by it, & again by agitating
ye particles of ye Cold bodies causes them to
grow warm or hot: hence it is yt a Thermome-
ter hung in vacuo wd undergo ye same changes
as in open Air; A Phænomenon no other-
wise to be accd for. We shall 2dly premise
yt if ye Æther is Capable of rarefaction by
heat, a greatr heat wd always cause a greater (rarefaction)
3dly the more ye Æther is rarefied ye less forcible
wd be ye effts of its vibrations cæteris paribus,
wch granted, let us suppose 2 Hot Bodies A & B
placd in ye confines of two equally cold ones C
& D, & let A be supposd to be twice as hot as
B; I say if ye Æther be Capable of rarefact
ion, A tho it be twice as hot as B wd perhaps have
no greater effect upon C yn B upon D, tho' exactly ye
same

cor ye Ambient aether about A being (by Suppn ye 2d) twice as much rarified as ye Ambient aether about B its vibrations must (by suppn 3d) be but ½ as strong as ye vibrations caused by B; but since A = ye wh of force 2 upon ye Quantity of aether & B = ye wh of force 1 upon ye Quantity of aether 2 it follows yt ye Quantities of motio or heat communicated must be equall yt is yt wch A communicated to C must upon ye whole be precisely eq. to wt B communicates to D & no more; but since we find by Experience yt hot bodies communicate heat to cold ones more or less in proportion as they are heated, it follows yt ye aether or medium whereby heat is communicated, is not capable of rarefaction by heat. —

No 5. 4thly were it possible for ye aether to be rarified or warmed by heat tis yet impossible yt these Circulatory Vapours shd be buoyed up by it: for if it be true yt ye aetherial medium is void of all resistance (as it must needs be according to ye Nature of things as Sr Isaac

Newton absolutely affirms it is in y^e very 39
prop^n where he treats of Comets there exhalations
c^d never be carried up by it; for to suppose
a fluid void of all weis^t is to suppose it
void of all pow^r of communicating motio
to or moving any body at all any way or
other. 5^thly y^e Circumgyration of a Comet
round y^e Sun can't be y^e cause of y^e tail (appears)
114. fro y^e because y^e orb^ts of y^e Comets are so very
excent^ric y^t their motio (except in orb^ts
y^e sides) is very nearly rectiline ar.
how therefore is it possible for so insensible
& minute a circumgyratio to have so very sensible an eff^t
118: Aristotle, & others of y^e Peripateticks thought
y^t Comets were only sublunary vapours &
Meteors: but tis plain they are above y^e Moon
by y^e smallness of their parall^x; y^e Moon
has a sensible parall^x but few Comets have
as Hevelius & other Astronom^rs have observ'd
w^ch utterly overthrows their Hypothesis of
their being below y^e Moon: y^t they are not
Meteors or vapours appears from y^e great heat

10

They must contract in Perihelio w^ch w^tout y^e 392
Dispers & w^ch did they not Consist of a Sub^t
very fix'd & durable, if they are not in y^e
region of y^e fix'd Stars as some have Imagin'd
is argu'd fro their being Illuminated by
y^e Sun: w^ch c^d not be done were they also
great a Distance.

119: There have also been diff^t opinions Concerning
y^e tails of Comets. Some have Imagin'd
y^e tail of a Comet to be nothing but y^e
Suns Rays Shining thro y^e head of it
as they do thro a Crevice into a darkness,
but y^t Notion w^ll not hold because y^e reason
why y^e Suns beams appear Lucid w^n
they Shine into a dark room is because y^e
Light is reflected fro y^e particles of smoke
& dust, w^ch Continually float in y^e
Air; but tis impossible such an appearance
s^d be in y^e Celestial regions where
there is no reflecting matter.

120: Others w^d have y^e tails of Comets to be
by y^e ~~[illegible]~~ refraction of light as it
passes thro y^e head of a Comet to y^e Earth.
but y^s opinion is insufficient. ~~w~~ because
these tails are never adorn'd w^th va~~[illegible]~~rious
Colours, w^ch are y^e [illegible] inseparable con-
-sequence of refraction.

2dly ye Light of ye fixed Stars and planets coming to us directly & being transmitted distinctly shows yt ye Celestiall medi-ums have no refracting power: Lastly were these Phænomena effected by ye shining of ye Suns Light thro ye Comet tow.ds us, it follows yt in ye same regions of ye Heavens ye tails wd be always reflected tow.ds ye same pt of ye Heavens, wch is found to be false by undoubted observa-tions; Consequently yt cannot be ye true Cause. & thus we have explained ye Phænomena not only of all ye planets & Comets but also of ye fixed stars wch acct of ye whole Mundane system is built upon ye principles laid down by Copernicus improved by Kepler & carried on to great degree of perfection by Sr Isaac Newton. nothing now remains but to establish ye foregoing System partly by Confuting ye other Hypotheses & ptly by answering some objects made against this.

121. The Annual & Diurnal Motions of ye Earth were maintained by ye Egyptians & Chaldeans long before ye Study of Astronomy was in use amongst ye Greeks. Pursuant to ym Pythagoras (who flourished abt ye 60th Olympiad 530 yrs before Christ) borrowed ye System & taught ye Greeks, yt ye Sun stood still in ye Centre of ye World. but yt opinion was afterwds rejected by Ptolemy (who flourished Anno Dom. 140 in ye reign of Antoninus Pius) as contradictory to our senses.

122. He maintained ye Earth to be immoveable in ye Centre of ye Universe & yt ye Sun & planets moved round it in a Circle, as 1st ye Moon 2d Mercury 3d Venus: above Venus he placed ye Sun 4th Mars, Jupitr & Saturn, beyond Saturn he placed ye Sphere of ye fixed Stars, wch Sphere he supposed to move slowly fro East to West on ye Poles of ye Eclipt. whilst ye fixed Stars & all ye planets moved fro East to West on ye Poles of ye Aequator in ye space of a Naturl day or 24 hours. vid. Clerc. Phys. l.1.c.2.

123. Ab.t ye yr 1540 Copernicus rejected ye Ptolamaick
(wch had hitherto been recd) & revived ye Pytha-
-gorick system maintaining yt ye Earth & all ye
planets revolve round ye Sun & not round
ye Earth, wch wd put out of doubt as soon
as ever ye telescopes acquainted us wth ye
various Phases of Venus & Mercury; for wn
it became apparent yt their orbits included ye Sun
124. Earth, Tycho Brahe invented a System
betw ye Ptolamaick & ye Copernican;
for he supposed wth Ptolemy yt ye Earth
was fixed in ye Centre of ye Univers & conse-
quently yt all stars & planets moved round
our Earth in 24 hours. He supposd also
yt ye Moon moved round our Earth as ye
Centre of her motion: but as for ye other 5 planets
Saturn Jupiter Mars Venus & Mercury
he maintained yt they revolve abt ye Sun
in their proper Periods, as ye Sun did
round ye Earth in a years time; there was
also a Hypothesis call'd ye Semitychonick
as agreeing wth ye Tychonick excepting
yt whereas ye Tychonick makes ye Earth to have

no motion at all of Semicyrcle wch makes 396
it move round its own Axis & agrees
wth ye Copernican. but howevr tho these
Hypothesis by reason of ye many diffi
culties wherewth they are pplex'd had
but few espousers yet ye observations of
Tycho were very serviceable upon another
acct. for ye their Axis Kepler made such
discoveries in Astronomy as quite
Cleard yt Science fro some difficulties
It yt laboured under. — — —
125: The Ancients observd yt sometimes ye plant
moved fastr & sometimes slower, yt they
seemd sometimes greatr & sometimes less;
fro whence they very reasonably conclude
yt they were sometimes farther & sometimes
nearer; in particulr ye Sun seemd to
move $\frac{1}{15}$ fastr & his apparent Diamr
was $\frac{1}{15}$ largr in wintr yn in Summer: to
solve ys they found it Necessary to intro
duce Eccentrick Circles into ye planetary
System; but here in did their Hypothesis
fail; if they endeavourd to find ye place
of any plant their Calculations wd not
hold good — — —

Except in perihelio & Aphelio: But Keplar solv'd ye difficulty by discovering yt ye orbits of ye Planets were Elliptical not Circular: he also found yt ♂ ☿ & ⊕ were more Elliptically yn ♀. ♃. ♄; wch agrees very well wth ye observations of ye Ancients; for they found yt their Calculations held truer in ye 3 last yn in ye former Planets. Keplar was also ye first discoverer of ye harmony between ye dist. & ye periodic times of ye Planets but ye reasons of ye Harmony & true Physical Causes of all ye Celestial Motions, as they have been deliver'd above. were first discover'd & demonstrated by Sr Isaac Newton: so yt at present Astronomy is brought to a greater perfection yn any other part of Natural Philosophy.

We shall conclude wth answering Some of ye Args. agt ye Copernican System.

126: First. it is objected yt if ye Earth mov'd from West to East there ought to be Constant Winds blowing from East to West: but tis answer'd yt ye same Rotation is impress'd by

the Earth upon ye Atmosphere as it has it Self, consequently ye Rotatio of ye Earth do cause such Winds: ye Constant Winds be tween ye Tropicks are not owing to ye rotatio of ye Earth but to ye Suns perpendicul. Rays rarifying ye Air. —

127. 2dly. if ye Earth moved ye Centrifug. Force of ye Equator: parts wd be so very great, as that ye those parts ought to fly off. But this is answered, ye ye Force of gravity as appears fro Calculatio is 360 times greater yn ye Centrifugall Force even at ye Equator. —

128. 3dly. tis objected yt if ye Earth moves fro west to East yn a Bomb thrown Westwds & consequently meeting ye Earth ought to be more Efficacious & give a greater Shock to ye Wall or any thing it Impinges agst yn one thrown Eastwards. but tis not ergo. But we must know ye a Bomb or any thing else yt is thrown & seems to move fro East to West does not Imping against ye Wall but the Wall ~~[illegible]~~ (prop. speaking)

against it; for suppose ye Earth moves 399
wth 100° of velocity & suppose ye Explosio
-n gives ye Bomb 10 of Velocity ye Contrary
way yet ye Bomb doth not really move
fro East to West but it moves only wth 90
of Velocity fro West to East; it moves be
-fore as all things are supposd to do wth 100
of velocity & now, being destroy'd it moves
only wth 90; so yt ye Wall wch still continues
to move wth 100° is sooner wll overtake it
& Consequently strike it: again, if you
Combart a Bomb fro ye West side of it, ye
Bomb having 10 of Velocity communica
-ted it fro ye Explosion wll overtake ye Wall
& impinge against it; so yt now ye Bomb
will strike ye Wall wth 10 of Velocity & in
ye other case ye Wall will strike ye Bomb
wth 10 of Velocity: therefore ye Eff. be ye same
129:4. Tis objectd yt if ye Earth moved Eastwd
yt it ought to be more difficult to swim
westwards because against ye motion of ye
Earth: tho it may be ans. yt tis impossible
(absolutely speaking) to swim westwd, because

If a Person swims westw.d he must move Eastw.d westw.d y.t y.e Earth ~~[illegible]~~ does Eastw.d, w.ch is impossible to doe for y.e Earth moves 200 Miles in a minute; thus supposing y.e Earth to move w.th 200 of velocity Eastw.d y.e Man must move w.th 6, for w.d he to move only w.th 4 he might seem to move Eastw.d very swiftly, but w.d really have mov'd Eastw.d; y.e reason of y.e seeming to move westw.d w.d be because he w.d move more slowly Eastw.d y.n other Persons; again, relatively speaking it w.d not be more difficult to move westwards y.n Eastw.d, for he might as easily seem to move w.th one degree westw.d as Eastw.d & so really move with one 4 westward as he can apparently move w.th one degree Eastw.d & Consequently, really w.th 6 Eastw.d; for in both these Cases he is only to move himself (i.e. by his own strength) w.ch requires no more strength one way

y^n another; y^t may also be apply'd to Birds flying in y^e Air.—

130: 5^{thly} there is an object^n brought of more force y^n any of y^e foregoing w^{ch} is taken fro y^e Defect of a Sensible Parall^x of y^e first Stars, w^{ch} has been sufficiently answer'd in Sect. 90, 94, 95, 97. — —

Finis coronat opus

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